POWER

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HELPFUL HINTS

Inefficiency of "Bawling Out" Workmen

Nothing is more discouraging, and more out of harmony with efforts for best results and high efficiencies, than a severe "bawling out"

NOTHING is more discouraging, more out of harmony with efforts for best results and high efficiencies, than a severe "bawling out" of an employee by some one in authority. It is more discouraging if it occurs within the hearing of other employees.

Employees make mistakes, and so do you. Men may fail to understand you, but it may be your fault that they did not understand. In any event, you don't increase the employee's regard for you by "bawling him out" for he then grumbles to himself and to other employees, and probably calls you a string of hard names when you are out of hearing. He is losing time while he is grumbling, and so are his fellow-workers who are listening. If you've "bawled out" one man you probably have the others at some time, and they are stopping work to tell their grievances and to sympathize with the last victim of your harsh words.

Employees are men; if they are not, it's probably your own fault or some other boss for whom they have worked. You don't have to hire them, nor keep them if they don't satisfy you, but why disconcert your whole operating force by a practice that creates discord?

Discord is never efficient. Men don't accomplish best results when they are nursing a grievance. It is proper to correct mistakes, and to explain, but unless the workman is hard of hearing, don't yell at him. And don't allow any of your foremen to "bawl out" any of their men. A foreman who generates discord among the workers is as dangerous as any other agitator stirring up dissatisfaction. The result among the employees is the same. For efficiency it is necessary to have harmony.

If a foreman dislikes a man, it is a hundred to one that the man dislikes the foreman. No one works as easily, and peaceably, with as good results, for a man he dislikes as he does for a man he respects, admires and likes. Do you know any one whom you thoroughly dislike who loves you?

If all the men dislike the foreman, and new men coming into the works grow to dislike him, there is just one thing to do—fire that foreman.

If he is the inventor of some vital part of your product, and is so valuable that he cannot be dispensed with, promote him to the position of "advising manager," with a little increase in salary; but put a new foreman over the men. It will pay.

A foreman is a "teacher"—to instruct, correct and lead employees into bringing about the desired results. He should not be a driver. Whenever it is necessary to drive workers and abuse them and swear at them, or otherwise "bawl them out," there is something wrong with the men over them.

Just stop and think how you would like it if some fellow higher up than you would come in and bawl you out in the same way.

Contributed by LETSON BALLIET, *Tonopah, Nev.*

Operating Conditions at Newark, Ohio, Power Plant

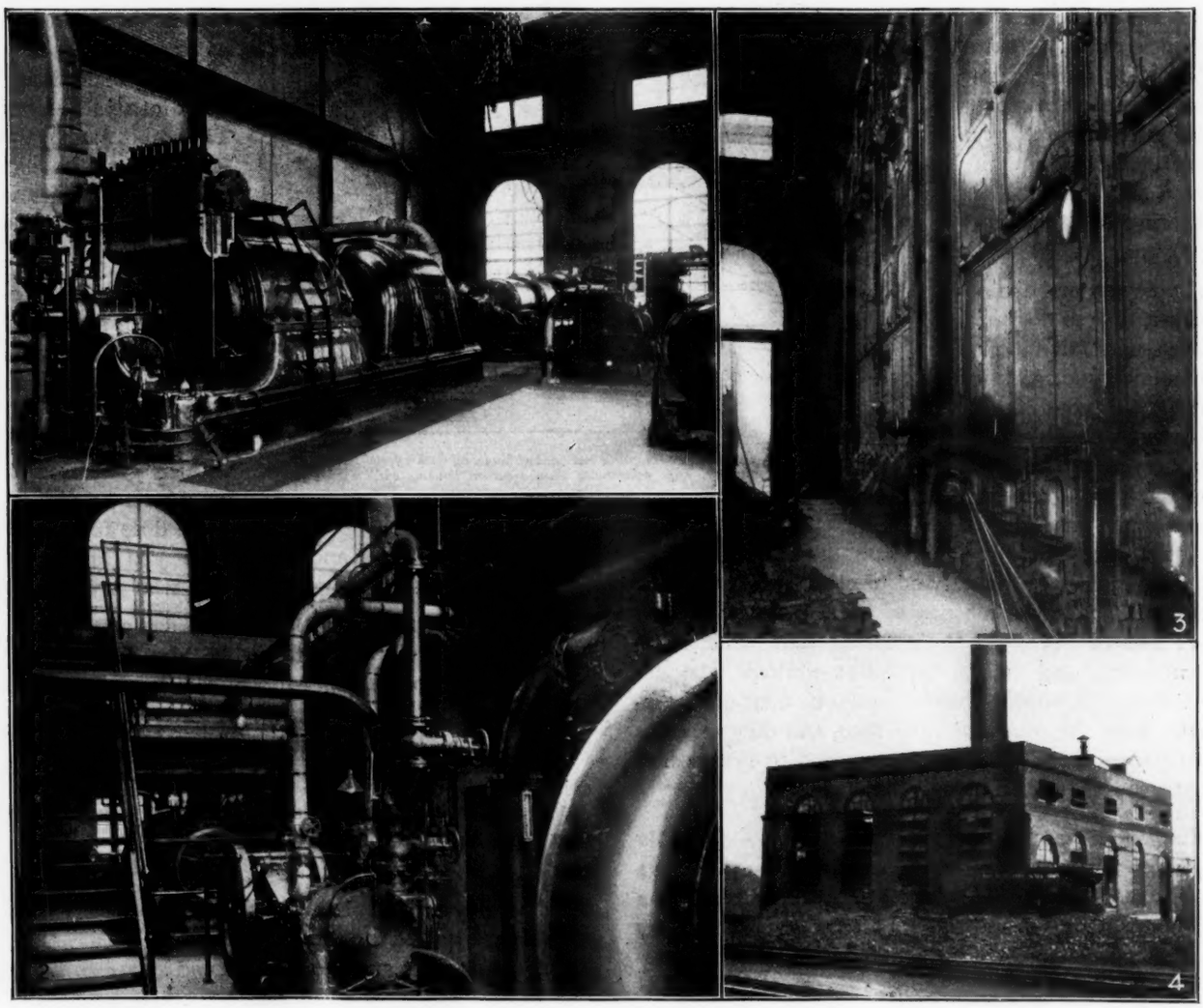
By W. O. Rogers

SYNOPSIS—This station operates with a remarkably low proportion of combustible in the ashes. The makeup water is less than 1½ per cent. of the total water used in the plant. All auxiliary exhaust steam goes to a vacuum feedwater heater. If the pressure exceeds 4 lb., the surplus goes to the main condenser; no exhaust steam escapes to the atmosphere.

Although the power plant of the Ohio Light and Power Co., Newark, Ohio, is of but 4,000-kw. capacity, it holds the record for the lowest percentage of fuel in the ashes of any of the eight stations operated by the American Gas and Electric Co., of New York City.

The boiler plant, Fig. 3, consists of four hand-fired water-tube boilers, each with 5,000 sq.ft. of heating surface and a furnace equipped with a shaking grate. The furnaces are 8 ft. deep by 10 ft. wide, giving a grate area of 80 sq.ft. in each, or 1 sq.ft. for each 62.5 sq.ft. of boiler-heating surface. A steam pressure of 200 lb. is carried, superheated 100 deg. F. The boilers are operated at about 150 per cent. of rating.

The draft is produced by a self-supported steel stack 200 ft. high above the boiler-room floor. It is 10 ft. inside diameter at the top. The draft is hand-controlled by a damper in each boiler uptake. Generally the damper is about one-half open under normal conditions. For the benefit of the fireman a registering draft gage is provided for each boiler and placed where it can be seen when manipulating the damper. This gage has a large dial over which a hand moves. Under normal load with clean fires, the draft is carried at 0.51 in., the pointer of the gage so registering. As the fires get dirty, the



FIGS. 1 TO 4. VIEWS OF THE NEWARK, OHIO POWER PLANT

Fig. 1—A partial view of the turbine room. Fig. 2—Condensing apparatus in the basement. Fig. 3—Boiler room. Fig. 4—Exterior of the power house

decreasing draft is indicated by the gage. With one furnace door open the draft is reduced from 0.51 to 0.37, or 0.14 in. This gives a good idea of how furnace leaks and open doors affect the furnace conditions of any boiler installation.

It is the practice to blow down the boilers once a week. Each is operated eight weeks before being taken from the line for inspection.

Coal is delivered to the plant on a spur track that runs on a trestle to the side of the building, Fig. 4. It is elevated by the motor-driven bucket conveyor shown at the right, and is dumped into a chute that discharges to a chain scraper conveyor running in a flat-bottomed conveyor box. In the bottom of this box are sliding gates 18 in. long. They are opened and closed by a handwheel and gear-operated rack, so that the coal can be discharged at any point in the bin in front of the boilers. Large sizes are prevented from passing to the bucket conveyor by a rod screen with 6-in. spacing placed above the conveyor hopper.

The method of handling the furnaces has everything to do with the small proportion of fuel in the ashes. Each furnace has three firing doors, and only one is opened for firing at a time. This rule is rigidly enforced. Furthermore, the firemen are not allowed to continue to shake the grate until fuel falls into the ashpit. The ashes are carried at an average depth of 2 in. With the general run of coal the fires are cleaned once in 24 hours and the grates are shaken about every 10 hours. As soon as one live coal falls into the ashpit, shaking is stopped. As the stack is high and produces a good draft, a heavy bed of ashes can be carried on the grates without affecting the economy of the furnace; the coal averages 13,000 B.t.u. per lb. as fired.

FIG. 6. THESE ARE THE BOYS WHO OPERATE THE NEWARK PLANT

Standing—David Hobbs, George Vance, C. Pollick, Charles Iden, C. E., Edward P. Wagenhals, Supt., J. Sullivan, Leo Christan, E. Yokes. Seated—John Terrill, O. Tanner, T. Huffman, J. Rissler, J. C. Farber, Charles Jacobs

PRINCIPAL EQUIPMENT OF OHIO LIGHT AND POWER CO.'S NEWARK, OHIO, POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Water-tube	5,000 sq.ft. heating surface	Steam-generators	200 lb. pressure, 100 deg. superheat, 250 per cent. rating	Babcock & Wilcox Co.
4	Gages	Draft, Westover		Registering draft	Automatic	American Safety Lamp Co.
1	Turbo-generator	Horizontal	1,500-kw	Main generator unit	4,000 volts, 3-phase, 60-cycle, 1,800 r.p.m.	Allis-Chalmers Co.
1	Turbo-generator	Horizontal	2,500-kw	Main generator unit	4,000 volts, 3-phase, 60-cycle, 1,800 r.p.m.	General Electric Co.
2	Condensers	Surface	8,000 sq.ft. cooling surface	With main turbines	Steam-driven air and circulating pumps	Alberger Pump and Condenser Co.
2	Pumps	Air	8x20x18-in	With condensers	Chain-driven	Alberger Pump and Condenser Co.
2	Pumps	Volute	18-in	With condensers	Engine-driven	Alberger Pump and Condenser Co.
2	Engines	Vertical	6x9-in	Driving volute circ. pump	Steam, 200 lb.	Alberger Pump and Condenser Co.
2	Generators	Direct-current	75- and 100-kw	Exciter units	125 volts, 2,400 and 900 r.p.m.	General Electric Co.
1	Motor	Induction	150-hp	Driving 100-kw. d.-c. generator	900 r.p.m., 4,000 volts, 3-phase, 60-cycle	General Electric Co.
1	Turbine	Single-stage	75-kw	Driving 75-kw. d.-c. generator	2,400 r.p.m., 200 lb. steam	General Electric Co.
1	Motor-gen. set	A.-c.—d.-c.	50-kw	Lighting and exciter current	700 r.p.m. motor, 4,000 volts, gen. 125 volts	General Electric Co.
1	Motor-gen. set	A.-c.—d.-c.	100-kw	D.-c. current for motor circuits	600 r.p.m. motor, 4,000 volts, gen. 250 volts	General Electric Co.
1	Heater	Vacuum feed water		Heating feed water	Utilizing auxiliary exhaust steam	Warren Webster & Co.
2	Pumps	Duplex	12x7x18-in	Boiler-feed water	200 lb. steam	Scranton Steam Pump Co.

A sample of ashes is taken from each ash car of 1,500 lb. A sample is also taken from each ashpit at the end of every watch. At the end of the week the samples are sent to the Scranton, Penn., laboratory for analysis. The report, Fig. 5, shows the result of an ash analysis taken at random from those kept on file at the plant. Each report shows what fireman is responsible for the showing, whether it be good or bad.

A record of the fireman is posted at the plant for inspection by the men. The men take a decided interest in the results obtained, and a keen rivalry exists for the honor of having the lowest loss of coal in the ashes.

This ash analysis is carried out in the same manner in the other plants operated by the company. Following is a report of averages for the month of March this year for the various plants:

LOSS DUE TO COMBUSTIBLE IN ASHES

Coal Loss Due to Combustible in Ash as Shown by Analysis of Samples of Coal and Ash from the Several Plants. Report of Averages, March, 1916

Plant	Per Cent. Comb. Loss	Equiv. Coal Loss Per Cent.	Est. Yearly Loss	Est. Yearly Saving If All = Newark
Atlantic City	4.55	5.14	$4,434	$1,869
Muncie	7.97	10.90	10,895	8,070
Scranton	9.65	12.72	9,240	7,017
Wheeling	4.24	4.83	2,591	951
Tiffin	5.25	6.40	2,901	1,029
Newark	2.59	3.12	524	.....
Fremont	3.28	3.70	707	121
Rockford	5.24	6.04	6,035	3,468
Canton*	5.96	7.21	8,322	4,783
Total	....	.....	$45,649	$27,308

* First, third and fourth weeks of month only.

Contributing perhaps more than anything else to the successful operation of this plant is the spirit of cooperation that exists. To begin with, the firemen are taken from the laborers about the plant and are advanced to better positions as they become fitted for them. This gives every man employed about the station an incentive to do his best. The family feeling that exists

SCRANTON ELECTRIC COMPANY
LABORATORY

Ash Analysis

Date December 14 1915

Analysis No. 663
From (Co.) Newark Ohio.
Sample No. Fireman Cooper
Date December 11, 1915

Volatile	2.00 %
Fixed Carbon	10.70 "
Ash	87.30 "
Total	100.00 "
B. T. U.	2000
Loss Combustable in Ash %	1.80
Equivalent Loss of Coal %	2.10

E V Wagner
Chemist.

FIG. 5. REPORT OF ASH ANALYSIS

is also shown to some extent by Fig. 6, a reproduction of a photograph taken of all the men employed, with one exception, on both day and night shifts. All are dressed alike except E. P. T. Wagenhals, superintendent. The men are encouraged to study for advancement by Chief Engineer Charles Iden and frequently secure positions in other plants as a result of their training.

The turbine room, Fig. 1, contains one 1,500-kw. and one 2,500-kw. turbo-generators, each delivering 4,000 volts three-phase 60-cycle energy and they supply four local circuits without transformers. The different long-distance transmission lines are supplied with energy from these units after stepping it up to 66,000 volts at the outdoor transformer station at the plant, Fig. 7.

All condensing apparatus is in the basement, Fig. 2. This consists of two surface condensers each having 8,000 sq.ft. of cooling surface. The circulating water for each is supplied by an 18-in. engine-driven volute pump.

There are two independent exciter units—one motor- and the other turbine-driven—each delivering 125-volt energy. The motor-driven set is of 100 kw., the turbine driven is of 75 kw. capacity. The 2,500-kw. turbine unit has a self-contained 125-volt exciter.

There are also two motor-generator sets, one driven by an 85-hp. and the other by a 150-hp. motor. One

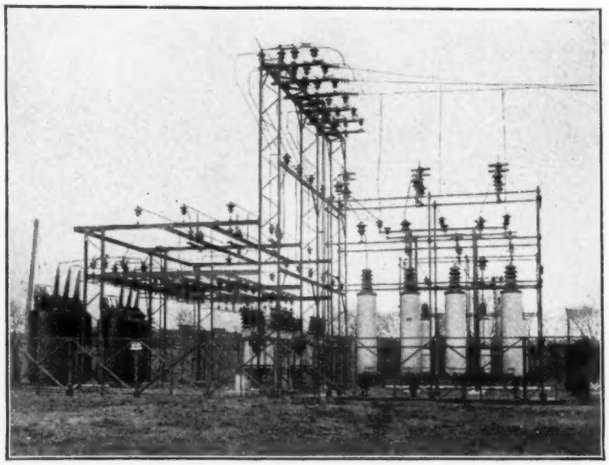


FIG. 7. OUTDOOR TRANSFORMER STATION

generates 125-volt current for house service, the other 250-volt current for motor service.

Feed and condensing water for the plant is secured from Licking Creek. The water carries considerable magnesia, and because of this and also because of economic conditions as little makeup water is used as is possible. In fact, it is lower than 1½ per cent., and this is possible because the exhaust steam from all the steam auxiliaries is carried to a vacuum-type feed-water heater, where all the steam is condensed if enough water is being used. In the event of excess exhaust steam in the heater, with a pressure greater than 4 lb., the steam passes to the condenser of the main unit. By this arrangement no exhaust steam escapes to the atmosphere. As an example of what this means, the total amount of water used the day before the writer visited the plant was 936,000 lb. and but 190 cu.ft. of makeup water, or 11,847 lb., was used, or 1.27 per cent.

This plant is the first, so far as known, to adopt this method of utilizing all the exhaust steam from the auxiliary units, and it was probably from this idea that the practice originated of piping the exhaust steam of condensing units into the lower stage of the main turbine in some of the other plants of the company.

The boiler room is where the greatest preventable losses occur, and in this plant an effort is made to secure the best possible operating economy. To assist in keeping in touch with the boiler-room operation, a pyrometer is installed in the chief engineer's office. It is so connected that the temperature of the gases and the breeching of any boiler can be regulated at any time. The temperature determined by the thermocouples is registered by a recording gage, the time of taking the temperature of the gases being shown for any particular boiler.

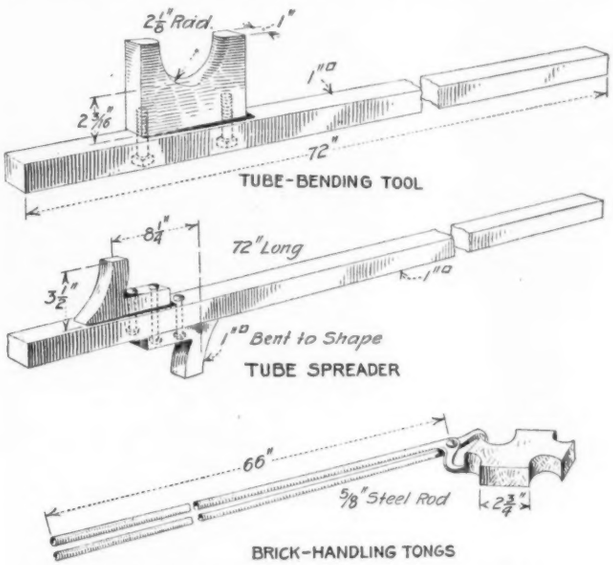
There is also installed a continuous CO_2 sampling outfit. This apparatus was designed by Thomas G. Coghlan, efficiency engineer of the company. It is the practice to take a sample of gas at the end of each fireman's watch, although one can be taken at any time. There is also in the engineer's office a recording steam gage.

This station is under the control of Frank Espy, general manager; E. P. T. Wagenhals, superintendent, and Charles Iden, chief engineer.

Tools for a Water-Tube Boiler

By D. A. Hampson

A lighting station used a battery of four 300-hp. Babcock & Wilcox boilers, and in the care and upkeep of these the need of several tools was felt. These were to be purchased in the market, but the engineer decided to have a set made at a near-by forging shop and have them of a size that was suited to these particular boilers.



BAFFLING TOOLS FOR THE BOILER ROOM

The drawings show these tools and need little explanation. The tube-bending and spreading tools are made of steel and are long enough to reach up in among the tubes. The brick-placing tongs are most convenient for setting the new baffle bricks in their hard-to-reach location.

Terry Duplex Exciter Set

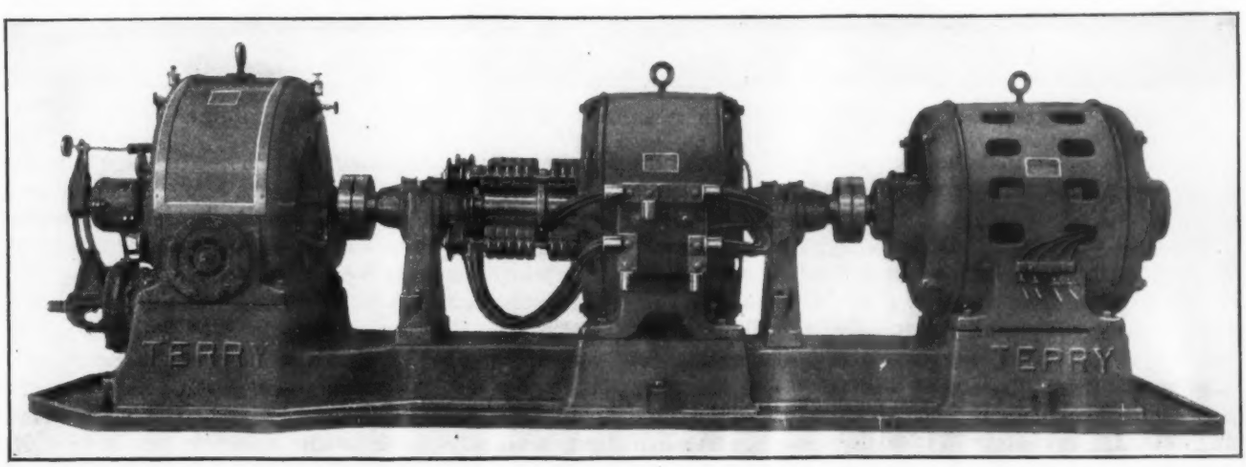
The exciter is one of the most important pieces of apparatus in the alternating-current power plant; a failure of the exciter means a failure of the main units. From the standpoint of reliability the ideal exciter drive is steam, and this proves a most economical drive where all the exhaust may be used for heating the feed water. In many stations, however, all the exhaust steam from the exciter drives cannot be used for heating; this results in a loss by blowing off steam from the heater.

From an economical standpoint the motor-driven exciter is often more efficient than the steam-driven. The serious objection to this type of drive is that when anything happens to interrupt the current supply to the exciter motor, the excitation is immediately lost and the main units are out of commission until some auxiliary exciter can be started.

With these facts in mind the Terry Steam Turbine Co., Hartford, Conn., has designed and placed on the market what is termed a duplex exciter set. One of these sets is shown in the illustration and consists of an exciter-generator coupled to a motor at one end and to a steam turbine at the other end. For normal operation the set runs as a motor-generator. Should anything happen to interrupt the supply of current to the motor, or should anything happen to the motor itself, the speed will drop slightly, the governor of the turbine will immediately take hold and the machine will then run as a direct-connected turbo-exciter. The action of the governor that is fitted to the sets is so sensitive that when the switch controlling the motor is pulled, the turbine will instantly take hold of the load without any appreciable fluctuation in the voltage.

The turbine governor is also fitted with a speed-changing device that is used during normal operation to divide the load between the turbine and the motor, so that the unit can be operated at its maximum efficiency at all times. With this device the proportion of the load carried by the turbine can be varied at will from zero to 100 per cent. to supply the proper amount of steam needed to maintain the proper heat balance in the feed-water heater.

Selecting Oil may be best done by trial, like the proverbial pudding, and when a satisfactory mixture is found, have it analyzed and require the same ingredients in the same proportions in future purchases.



THE TERRY EXCITER-GENERATOR COUPLED TO A STEAM TURBINE AND ELECTRIC MOTOR

Turbine Pumping Station Below Ground in San Antonio*

SYNOPSIS—Artesian-well pumping plant of the San Antonio Water Supply Co., which furnishes the supply of San Antonio, Tex. Greatest interest centers in a steam-turbine pumping station, the floor of which is about 47 ft. below the original ground level.

The San Antonio water comes from artesian wells varying in depth from 800 to 1,000 ft. Under normal conditions these wells flow with a head of 12 to 15 ft., but in times of extreme dry weather the head has been reduced. In order that the company might control the supply, the pumps were placed as far below the surface as was practical.

The main pumping station is in the business section of the city, on the banks of the San Antonio River, and derives its supply from 11 wells 8 to 12 in. in diameter. The pumping equipment was installed several years ago and consists of two triple-expansion Allis-Chalmers high-duty pumping engines, one of 25,000,000 and the other of 30,000,000 gal. daily capacity. These maintain a pressure in the mains of from 75 to 90 lb. per sq.in. and pump into a direct system of distribution—without even a standpipe. The high- and low-service lines are connected—but through check valves, automatic valves, and electric valves operated from the high-service station so that the relative load on the stations can be adjusted.

To supplement this supply and furnish service to the high-pressure district of the city, a new pumping station has recently been completed in Brackenridge Park, near some other wells in an outlying section of the city (see Fig. 1). On account of the high elevation of the ground in this locality, it was necessary to adopt unusual methods in the design of this station so that the pumps could be in a controlling position relative to the hydrostatic level of the wells. This was accomplished by excavating a bowl in the surface of the earth near the river and in this park, the embankment on the river side acting as a protection from floods in the river. The interior of the bowl was terraced. The bottom of the bowl is 2 ft. higher than the normal water level of the river so that generally the bowl drains into the river. At such times as it does not, the storm water is cared for by special pumps for that particular purpose. The main pumps were placed 35 ft. below the bottom of the bowl. The pumping equipment consists of two steam-turbine-driven centrifugal pump units, having a combined capacity of

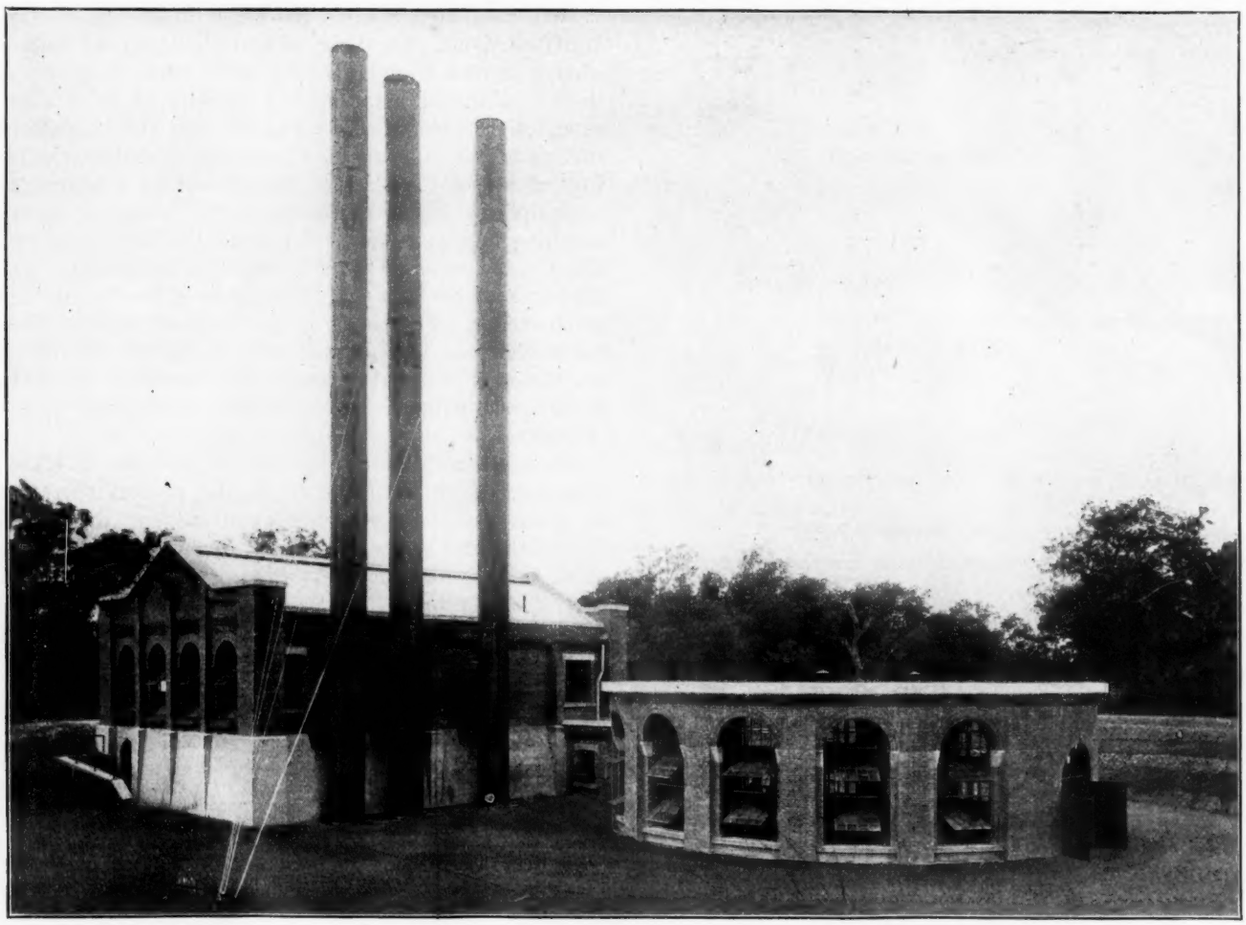
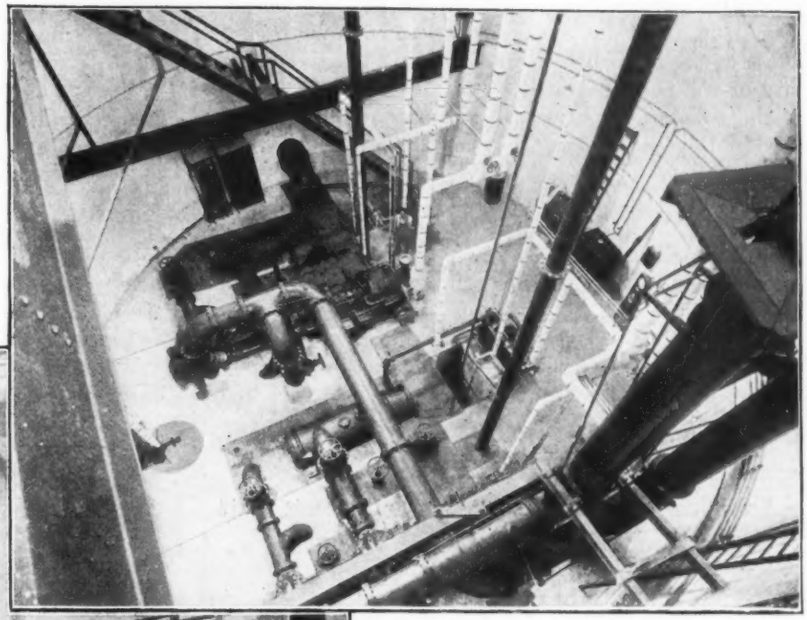


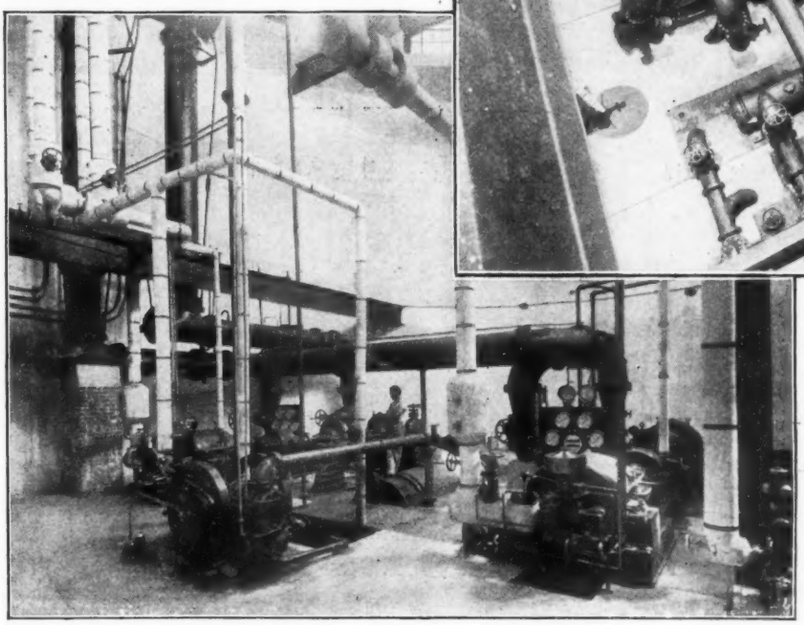
FIG. 1. VIEW OF BRACKENRIDGE PARK PUMPING STATION, SAN ANTONIO WATER-SUPPLY CO.

*"Engineering News," June 15, 1916.

reinforced concrete 1:2:4 mix. The roof is a 4-in. slab on I-beams, as in the case of the pump pit.

There are three 250-hp. water-tube boilers, each capable, without forcing, of evaporating 7,500 lb. of water per hr. at 150 lb. gage pressure. A working pressure of 170 lb. can be maintained if desired. Shaker grates for Texas lignite are installed; these are to be covered with firebrick during oil-burning periods and the burners set near the boiler front.





FIGS. 2 AND 3. INTERIOR VIEWS OF BRACKENRIDGE PARK PUMP PIT

Cast-Iron Radiation is built in height from 15 to 45 in., and from 1 to 5 columns wide and if well distributed will give off 1.7 B.t.u. per sq.ft. per hr. per deg. difference, but if wide high radiators are used this may be reduced to 1.5 B.t.u. If low radiators 5 columns wide are used, they are as efficient as the narrow, high radiators. Pipe coils and single-column radiators on temperatures averaging over 200 deg. will transmit 1.8 B.t.u. per deg. difference.

The Effects of Power Factor on Voltage Regulation

By F. A. Annett

SYNOPSIS—Voltage regulation of alternating-current generators, as affected by the inductance and capacity of the load. Why a lagging current decreases the generator voltage, while a leading current causes an increase.

In all alternating-current systems the relation between the current and the voltage is of vital importance. It is desirable that the power factor of the system be kept as near unity as possible; at this point the current and electromotive force are in step. A low power factor is objectionable for several reasons, chief among them being the effect it has upon the regulation of the generators. A lagging current decreases the voltage of the generators, while a leading current causes an increase in voltage.

To understand the effect of inductance and capacity in an alternating-current circuit on the voltage of an alternator, it will be necessary to consider the effect of the armature current on the polepieces. In Fig. 1, if the field coils are connected to a source of direct current of a polarity as shown, a current will flow in the coils which will establish a flux in the polepieces and armature core, as indicated by the dotted lines and arrowheads.

If the field coils are disconnected from the circuit and a current is sent through the armature winding, as in Fig. 2, consequent poles will be set up at *a* and *b* in the armature. The magnetic field of these poles will take the path indicated, which is across the pole faces at right angles to the lines of force set up by the field coils, Fig. 1. Blocking the armature so it cannot turn and exciting the field coil at the same time that the current is in the armature coils will establish two magnetic fields at right angles to each other. It is evident that the effect of the armature will be to distort the flux from one pole tip to the other, as indicated in Fig. 3. Theoretically, what is pushed away from one pole tip is added to the other; therefore, when the armature poles are midway between the main poles, they will have their minimum effect upon them. Furthermore, the poles of the armature being midway between the main poles, they will be at a maximum distance from them, which will also tend to cause a minimum distortion.

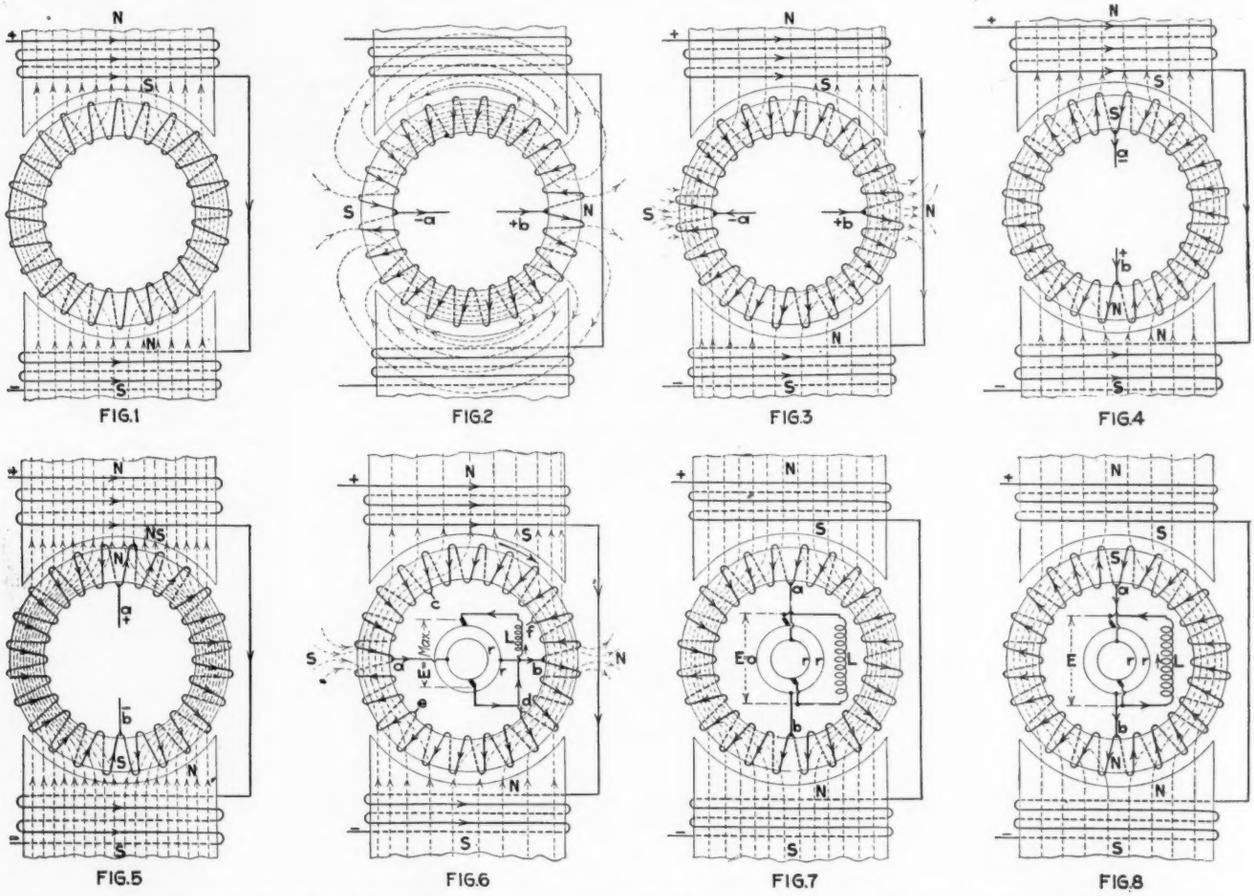
If the armature is placed in the position shown in Fig. 4, its magnetic poles will be located so as to oppose those of the main poles; consequently the magnetic density of the polepieces will be decreased or even reversed if the poles of the armature are stronger than those of the field poles. Since the armature poles are directly under the main poles, they will have a maximum effect upon them. On the other hand, if the armature is located as in Fig. 5, the effect of the armature poles will be to strengthen the main poles, as indicated. For the position shown, the armature will again have a maximum effect.

The effect of a lagging or a leading current in the armature of an alternating-current generator on the field poles is analogous to that shown in Figs. 4 and 5 respectively. Fig. 6 represents a single-phase alternating-current generator, which consists of the same arrangement of windings and polepieces used in the previous diagram, with points *a* and *b* on the armature connected to two collector rings *r*. Exciting the field coils and revolving the armature in the direction of the curved arrow will induce an e.m.f. in the direction indicated by the arrow-heads. When the armature is in the position shown in the figure, the e.m.f. between the collector rings will be at a maximum, because the pressure in all the conductors between points *a* and *b* is in the same direction. If the external circuit is closed through the load *L* a current will flow as indicated. The values of the current in the circuit will not depend upon the resistance only, but also upon the inductance and capacity of the circuit.

First, consider a circuit with resistance only. Then the current will be in step with the e.m.f. and at a maximum at the instant shown in Fig. 6. The direction of the current will be such as to produce consequent *N* (north) and *S* (south) poles at points *b* and *a* respectively. Since the current is at a maximum, the armature poles will be at a maximum strength, but as explained in Fig. 3, they will have a minimum effect on the main polepieces when located midway between them, as in the figure.

When the armature turns one-quarter of a revolution, as in Fig. 7, its magnetic poles will be directly under the polepieces and in a position to produce a maximum effect upon them, as described in Figs. 4 and 5. It is obvious in Fig. 7, however, that the e.m.f. between the collector rings is at zero, as the voltage in one quadrant of the winding opposes that in the other quadrant between points *a* and *b*. Since the current is in step with the e.m.f., it will also be zero, with a corresponding value for the flux in the armature poles. Consequently, when the current is in step with the voltage, the armature will have no effect upon the polepieces when in this position.

Where there is inductance in the circuit, the current will lag behind the voltage, as indicated by the curves Fig. 9, which shows that the current does not reach a



FIGS. 1 TO 8. SHOWING THE EFFECT OF ARMATURE REACTION IN AN ELECTRIC GENERATOR

Figs. 1 to 3—Represent armature reaction in a direct-current machine. Fig. 4—Armature poles opposing the main poles. Fig. 5—Armature poles assisting the main poles. Figs. 6 to 7—Alternator, current in step with the voltage. Fig. 8—Alternator, current lagging behind the voltage

maximum value until an instant later than the pressure. When a relation like that in the curves exists between the current and the e.m.f., the maximum magnetic poles of the armature will occur an instant later in the revolution than the maximum e.m.f. such as at points *c* and *d*, Fig. 6. This brings the *N* and *S* poles of the armature nearer the corresponding poles of the field. The maximum armature poles will now be in a position to oppose the main poles and weaken them. This latter statement is further exemplified by referring to point *a* on the curves. It will be seen that when the e.m.f. of

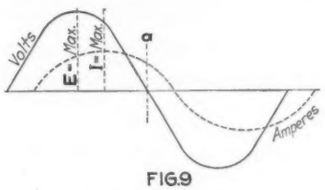


FIG.9

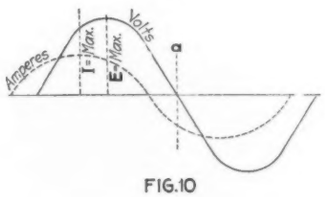


FIG.10

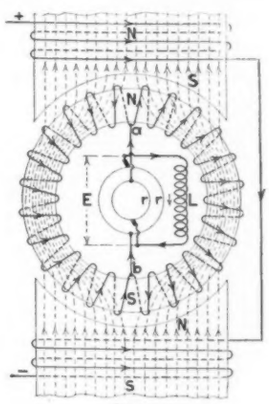


FIG.11

FIGS. 9 TO 11. SINE WAVES AND ALTERNATOR

Fig. 9—Represents a lagging current. Fig. 10—A leading current. Fig. 11—Alternator, current leading the voltage

the armature is zero, the current is of considerable value in the circuit. It has been shown that the e.m.f. between the collector rings is zero when the armature is in the position Fig. 7. If current is kept flowing in the circuit by the inductance of the load, *N* and *S* poles will be produced in the armature, which will oppose the main poles and weaken them, as shown in Fig. 8, which is the effect explained in Fig. 4. Therefore, if the generator e.m.f. is to be maintained constant, the field current will have to be increased.

On the other hand, if the current leads the e.m.f., as in the curves Fig. 10, the current will reach a maximum value an instant before the voltage; therefore, the maximum magnetic poles of the armature will occur an instant before the armature is in a position to generate a maximum pressure such as at points *e* and *f*, Fig. 6. The armature poles will now be in a position to assist the main poles and increase the voltage. The same effect is found to be true when considering the position of zero e.m.f. in Fig. 11. Referring to point *a* on the curves Fig. 10, it will be seen that when the e.m.f. is zero the current has reversed and is of considerable value. Since the current is reversed, the magnetic poles of the armature will be reversed from those in Fig. 8, and of a polarity to assist the main poles and increase the voltage, which means that the field current will have to be reduced to maintain a constant pressure at the collector rings. The maximum effect of a lagging or leading current on the polepieces occurs when the current is displaced 90 deg. from the e.m.f.; then the current in the armature would be at a maximum when the armature is in a position to generate zero e.m.f. at the collector rings.

In large alternating-current systems inductance and capacity may cause serious interference with voltage regulation, and means have to be taken to rectify it. Usually this is done with a synchronous motor or synchronous condenser. Both devices are the same in construction, each being an alternator run as a motor. When an alternating-current generator is run as a motor, the power factor of the machine may be changed from leading to lagging by varying the field strength. Increasing the field current above normal value causes the machine to have a leading power factor, and decreasing the field current below normal value will give the machine a lagging power factor. When the machine is called upon to do a certain amount of mechanical work, as well as power-factor correction, it is called a synchronous motor. When used for power-factor correction only, it is called a synchronous condenser. In the latter use it is usually operated in conjunction with an automatic regulator to correct the power factor and voltage of high-voltage transmission systems.

Belt-Drive Suggestions

By Lewis F. Lyne

It used to be the practice to place the flesh side of the leather next to the pulley principally for looks, as it was not then known by experiment that the grain side would pull much better and that the greatest strength of the hide was nearest to the flesh side of the

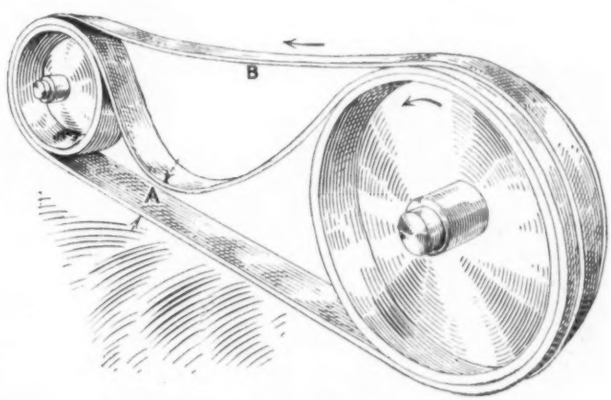


FIG. 1. SLACK BELT WITH RIDER

leather and therefore ought to be farthest from the pulley to get the greatest durability. Double belts are better than single for several reasons, one being that when two thicknesses of leather are cemented together face to face they stretch more nearly even than a single thickness would be likely to, as the inequalities in one side help to correct those of the other and both of the external surfaces of the belt are the grained side. Single thickness is used for narrow belts and light work only.

In a certain test of leather a strip was cut 7 in. wide and split through the middle of its thickness, and it was found that the half from the flesh side sustained a strain up to 740 lb., while the hair or grained side broke at 468 lb.

A handy rule for the horsepower transmitted by leather belts is, "A leather belt 1 in. wide traveling at 600 ft. per min. will transmit 1 hp.," and it has been found reliable.

Belt dressings and all preparations containing substances destructive to the leather should never be used to make a belt stick to the pulley, but reliable dressing ought to be used to make the belt soft and pliable and

to keep it so. One therefore ought to be very careful in the selection of a dressing to avoid any substance that will damage the belt or rot the leather.

When a belt slips, it is usually owing to overload and the arc of contact ought to be increased, which may

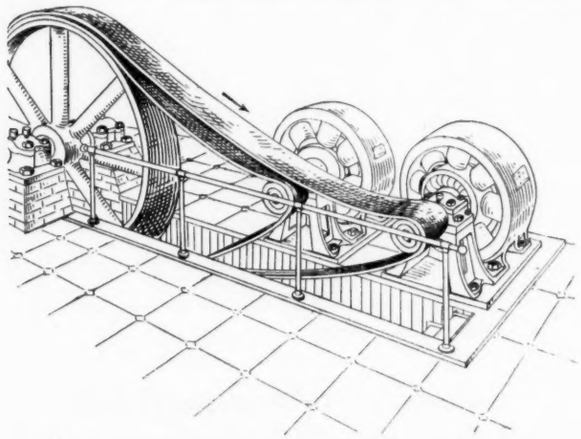
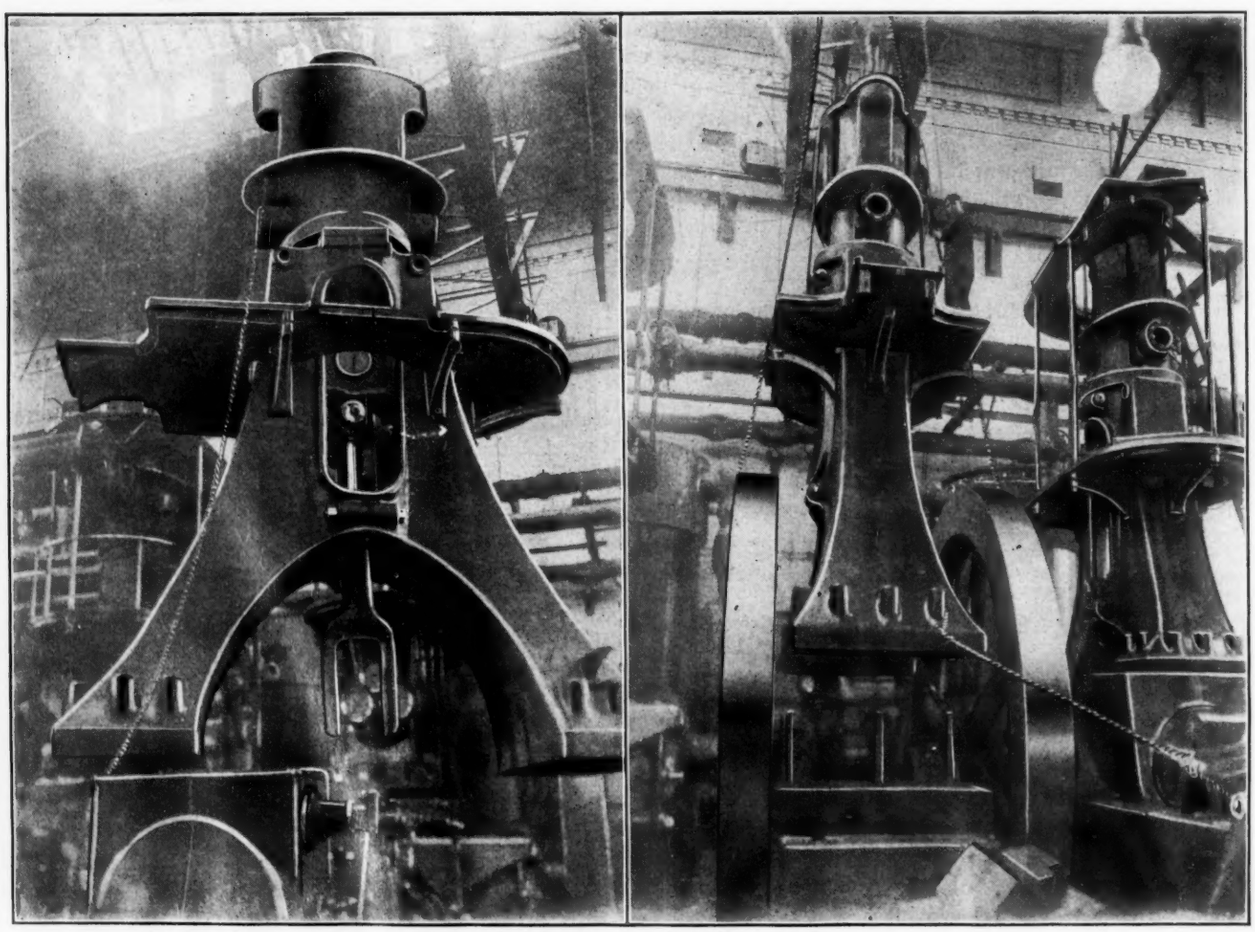


FIG. 2. DOUBLE DRIVE FROM ONE WHEEL

be done in a very simple manner by putting in a piece so that it will be slack, as shown in Fig. 1 at *A*. In one case the distance *A* was 1 ft. where the belt was 24 in. wide by 79 ft. long and ran from a 15-ft. wheel to a 6½-ft. pulley. The danger with such a transmission is the backlash when the load is suddenly thrown on or off, and to overcome this there was put on what is known as a "rider belt" 12 in. wide represented by *B*, which is put on with a moderate tension producing a steady motion.

In the early days of electric lighting the transmission shown in Fig. 2 was much used, and it is not infrequently seen at the present time, where it is necessary to drive two machines from the same wheel. Care must be taken, however, to see that the belts are kept in good condition, for should the under one give away, there is sure to be a wreck. Belts for such service, as well as all belts around electrical apparatus, should be endless. Laced belts will slip when the lacing passes over the pulleys, and besides they make a disagreeable hammering noise and are sure to give way eventually.

A Heating System to Be Efficient should be capable of a wide range in temperature or capacity and quickly adjustable to suit the varied requirements. Where the temperature of the medium is nearly constant, as with low-pressure steam, the only method of varying the heat supply is by shutting off and turning on the radiators, either by hand or automatically. When the steam pressure may be varied through a considerable range, there is room for adjustment, as each variation in pressure changes the temperature of the medium. Water can be varied in temperature through a range of about 120 deg., and as a rapid change is possible at any distance if the circulation is forced, it makes a desirable and efficient heating medium. Hot air can also be varied within a considerable range of temperature, but its specific heat limits its carrying capacity and makes the losses in transit excessive.



LIFTING THE A-FRAME, CYLINDER, PISTON, CROSSHEAD AND CONNECTING-ROD OF AN 800-TON AMMONIA COMPRESSOR AT THE QUINCY MARKET COLD STORAGE AND WAREHOUSE CO., BOSTON, DURING HURRIED ALTERATIONS

A 5,000-Hp. Silent-Chain Drive

By John R. Allen*

SYNOPSIS—The waterwheels for this development were designed for a head of 42 ft. and a speed of 225 r.p.m. Owing to lack of head, their operating speed was 147 r.p.m. By connecting two wheels to the generator shaft through silent-chain and sprocket drive the speed of the generator was stepped up to 225 r.p.m.

At the time of the construction of the present temporary plant the Oxbow Bend power house of the Idaho-Oregon Light and Power Co. presented a peculiar engineering problem. The plant is located near Copperfield, Ore., at what is called the Oxbow Bend of the Snake River, about 60 mi. north of Huntington. It is 2½ mi. around the bend of the river, and the distance across the bend at the narrowest point is only 1,300 ft. The natural fall in the river in passing around the bend is 21 ft.

It was the original intention to build a dam across the Snake River, raising the water so as to give a head of 42 ft. at the power house. The tunnel across the bend was entirely completed, also the headgates at the entrance to the tunnel. The company having charge of the original construction had also purchased the waterwheels and two of the generators. The waterwheels had been purchased for a head of 42 ft., at which their speed would be 225 revolutions. At this point in the construction the company was forced to stop operations, owing to lack of funds, and the construction work was left for about three years.

In the meantime the company was placed in the hands of a receiver, who found himself very much handicapped for lack of power. There was also a possibility that if this power house was not completed the company's water rights in the Snake River would be forfeited. It was desirable, then, that this construction work be made use of as far as possible in building a temporary plant. It was at this point that I was called on to advise the company in regard to what could be done to obtain power from the Oxbow plant without expending any large sum of money. The amount of money available made it impossible to build a dam, as originally planned, or to buy new machinery. The problem was to use the construction work, the waterwheels and the generator already owned by the company and to combine them into an operating power plant sufficient for the purpose.

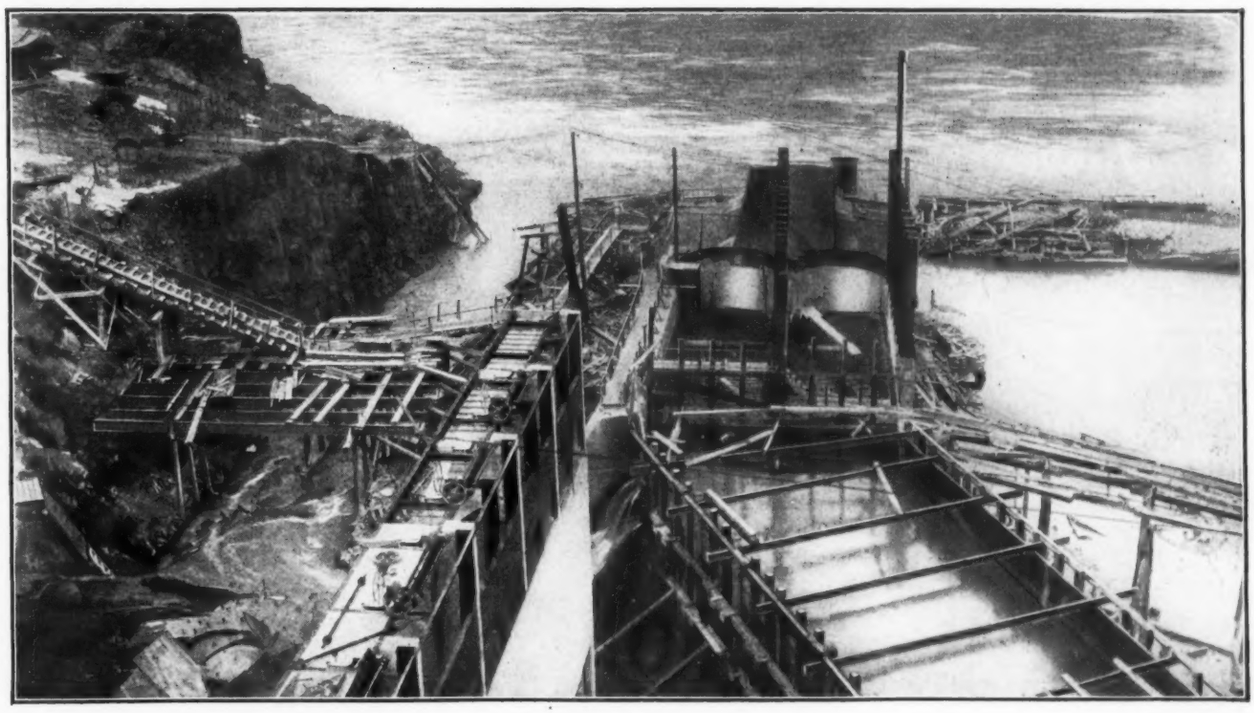


FIG. 1. A GENERAL VIEW OF THE PLANT

One of the difficulties was in the fact that the generator was designed for 225 revolutions and must be operated at that speed. The waterwheels at 21-ft. head would have a normal speed of about 147 revolutions and at the lower head would develop less than one-half the horsepower required by the generator. It was decided that, if possible, the experiment would be tried of driving one generator from two waterwheels, provided some form of geared drive could be employed to give the proper speed ratio between the generator and the waterwheels.

The first consideration was the use of large miter gears. These were seriously studied, but were given up owing to the difficulty that would be encountered in the gears being so large as to cut into the tailrace and prevent a proper discharge of water from the wheels. In addition, the expense of very large gears, such as

*Professor of mechanical engineering, University of Michigan.

would be necessary in this case, the shafts being 10 ft. 9 in. on centers, would be excessive. There was also suggested the possibility of using a crank and connecting-rod drive. This, too, was rejected owing to the many difficult problems involved in construction of this kind.

the concrete-steel penstocks in which are located the waterwheels. The wheels consist of four 48-in. wheels on a single shaft, there being two such sets.

A general view of the plant is given in Fig. 1. One set of chains and the generator are shown in Fig. 2.

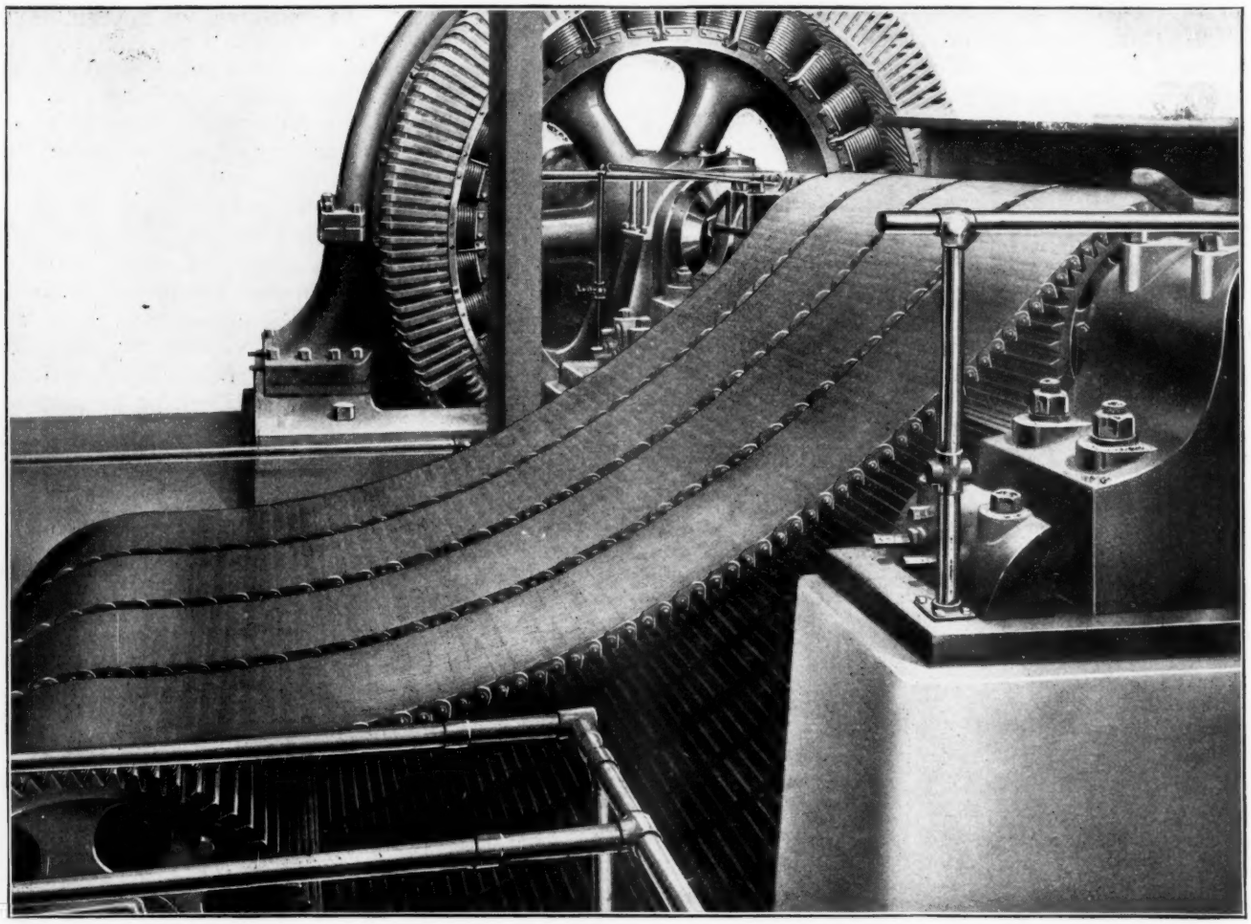


FIG. 2. ONE SET OF CHAINS AND THE GENERATOR

The third means considered was a silent-chain drive, which involved less expense and took up less space than any other form of drive proposed. In laying out the temporary plant it was found that it would be necessary to lower the wheels 5 ft. from their position as originally planned, in order to obtain a sufficient head of water over them in order not to draw air. The lowering of the wheels brought the waterwheel shaft very close to the floor of the power house, but by the use of a chain drive the sprocket wheels were reduced to so small a size that they did not cut into the engine-room floor to any depth. Previously to this time no silent-chain drive had been made for more than 1,250 hp., and it was with some misgivings that plans were made involving the transmission of 5,000 hp. The question of using so large a drive was taken up with firms making chains of this type and the contract was awarded to the Morse Chain Co., Ithaca, N. Y.

The hydraulic tunnel is 26 ft. wide, 26 ft. high and 1,300 ft. long. When the plant is in operation, the velocity of the water through the tunnel is about 7 ft. per sec., with a loss of head of about 1 ft.

A temporary tailrace of timber and steel was built to carry the water from the lower end of the tunnel to

Fig. 3 shows a layout of the shafts, sprockets and chains. The power house is built of monolithic concrete construction up to the roof. The entrance is through the roof. This construction was necessary, as at times of high water the power house may be submerged to a depth of 8 ft. above the operating floor. One peculiarity

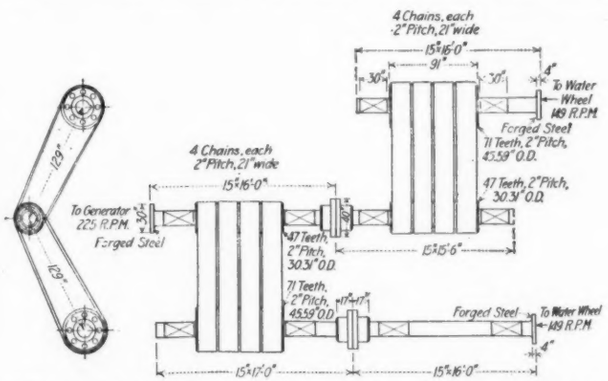


FIG. 3. LAYOUT OF SHAFTS, SPROCKETS AND CHAINS

of this plant, however, is the fact that during periods of high water the level of the headrace rises about as much as the level of the tailrace, so that an approxi-

mately uniform head of water can be obtained at the wheels at all times.

The plant has now been in operation since September, 1914, and the only shutdown that has occurred has been due to ice trouble. The chains have given satisfaction. The operation of the chains is almost noiseless, and the sound made by the revolving armature of the generator is much more noticeable than the sound of the chain. In the drive there are eight chains, each 21 in. in width with a 2-in. pitch. The driving sprockets have 71 teeth, and the driven sprockets 47 teeth. The distance from center to center of the shafts is 129 in. The linear speed of the chain is 1,765 ft. per min. The main shafts are 15 in., and the main bearings are 15x30 in. Each sprocket is supported with a ring-oiling main bearing close to the sprocket at each end. From the first day upon which the plant started, the chains and operating mechanism have run without difficulty of any kind.

Spraying Condensing Water

By Norman E. Horn

SYNOPSIS—An article dealing with the reduction of the temperature of condensing water as accomplished by the spray-pond cooling method. Why it is necessary to subdivide the water into small globules and why too fine subdivisions are wasteful.

Steam engineering has one important exception to the general rule that heat must be conserved wherever possible, and it is necessary because of the problem arising from the presence of the latent heat in steam that has been expanded to low pressure. It is mechanically impossible directly to convert this latent heat into power. To approximate the highest possible efficiency in the engine, it is necessary to create a vacuum by condensing the exhaust steam, when the latent heat of the steam must be dissipated.

How to get rid of this heat, amounting to 970 B.t.u. per pound of condensed steam, economically is a problem almost as important as conserving it prior to the steam being exhausted from the engine.

Circulating cooling water through a condenser to absorb the heat is the only practical method. But often where a large supply, such as a lake or a river, is not available, repeated use of the cooling water is necessary. The heat transferred from the steam to the water must be removed so that the water will be cooled enough when recirculated to maintain a satisfactory vacuum in the condenser. The available medium to which the heat may be transferred is the atmosphere.

The problem, therefore, resolves itself into this: How can heat in a quantity of water be transferred to the air at least expense and with reliability? When the latent heat of the steam is extracted in the process of condensing, about 970 B.t.u. per lb. of condensate is absorbed—enough heat to raise the temperature of nearly 970 lb. of cooling water one degree—barring some small loss from radiation.

To operate efficiently, cooling water should be at least 22 deg. cooler than the steam in the condenser. This would give a ratio of cooling water to condensed steam of 970 to 22, or, roughly, 44 to 1. In actual practice a slight margin is allowed, making the ratio about 50 or 60 to 1, depending on many conditions, such as the vacuum desired, average humidity, temperature conditions and the use in connection with reciprocating engines or turbines.

The condensing water on coming from the condenser has a temperature 20 to 22 deg. higher than it can have when it is returned. The atmosphere that must absorb this heat from the water can receive it in three ways—by convection, by radiation and by evaporation. This last may be considered as a heat transfer to the atmosphere, although strictly speaking, the heat absorbed by evaporation becomes latent heat in the vapor evaporated.

Each of these operations is accelerated by increasing the relative area of the water exposed per unit of volume. That is, evaporation, radiation or convection will occur more rapidly if the exposed area of a given volume of water be increased.

The solution of this problem by the cooling-pond method is to employ a system of pipes and nozzles through which the water is pumped and sprayed into the pond. To understand why spraying is effective in cooling water, assume that the water in the pipes is a series of globules of water, each the diameter of the inside of the pipe. As these units reach the nozzle, they are whirled apart and scattered into a number of smaller globules, which, by the action of the air in retarding their velocity after they are thrown from the nozzle, are again divided into still smaller units.

The small particles of the spray freely permit the passage of currents drawn in on all sides up through the spray, cooling it by contact or convection, by radiation and by evaporation. The spray falling back into the pond is cooled enough to be pumped back to the condenser. The action of the sprays induces rapid currents of air to pass up through them.

While it is true that a continued increase in subdivisions would result in a greater increase in heat transferred, there is a point beyond which it is not advisable to go. The reason is that as the particles decrease in size, they are supported longer in the air and any considerable amount of wind might cause them to fall outside the limits of the pond. This loss, known as "drift loss," is in a well-designed pond practically negligible. Engineers specializing in this subject have determined the grade or weight of sprays which give most practical results, and have found that a properly designed system increases the capacity of a natural pond about 35 times. The heat in the water is rapidly absorbed by the surrounding air, and in addition the evaporation of a certain amount of water lowers the temperature of the remainder considerably—often several degrees lower than the air.

The cooling action of the spray system is not seriously affected by humidity conditions because the supply of air is so tremendous and the contact is so brief that the slightest capacity of the air to pick up moisture results in sufficient evaporation.

The spray method has several practical advantages. The first is that a spray cooling pond is comparatively low in cost, and with suitable piping and nozzles there is practically no depreciation or upkeep. In normal operation the cost of operation is low. In cool weather the spray system can be operated at very low pressures.

An important feature in connection with the system is the design of the nozzles used to break up the water. It is necessary that a nozzle be used that will sufficiently atomize the water, but to keep operating cost down, it is desirable that the nozzle be so constructed as to give the desired spray effect with the least possible pressure.

Troubles and Care of Ammonia Compressor Valves--III*

By A. G. Solomon

SYNOPSIS—It is not advisable to use a lead gasket between a safety head and the cylinder. If the leakage is considerable, the faces of the joint should be machined. Indications of leaky suction valves.

The vertical single-acting machines in most general use are the Frick and the York. Figs. 10 and 11 show the details of each respectively. The vapor from the evaporating coils enters the cylinder at the bottom and passes through the suction valve on the down stroke of the piston. On the up stroke the ammonia is discharged through the valve in the center of the safety head. On large units there are sometimes two or more discharge valves.

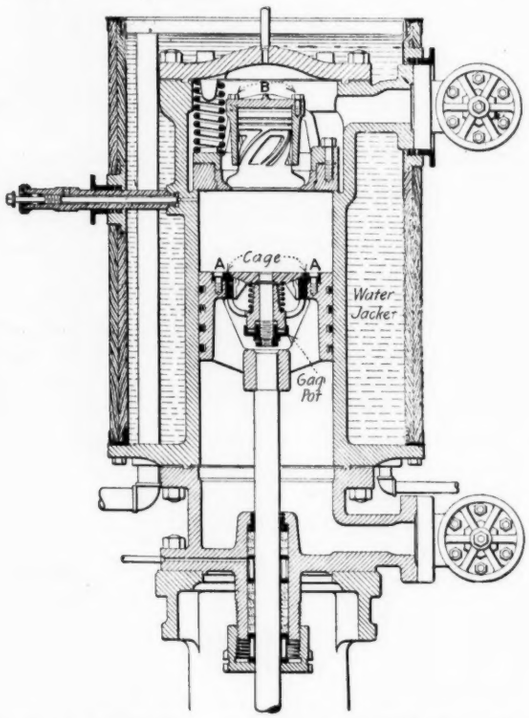


FIG. 10. SECTION OF THE FRICK AMMONIA COMPRESSOR CYLINDER

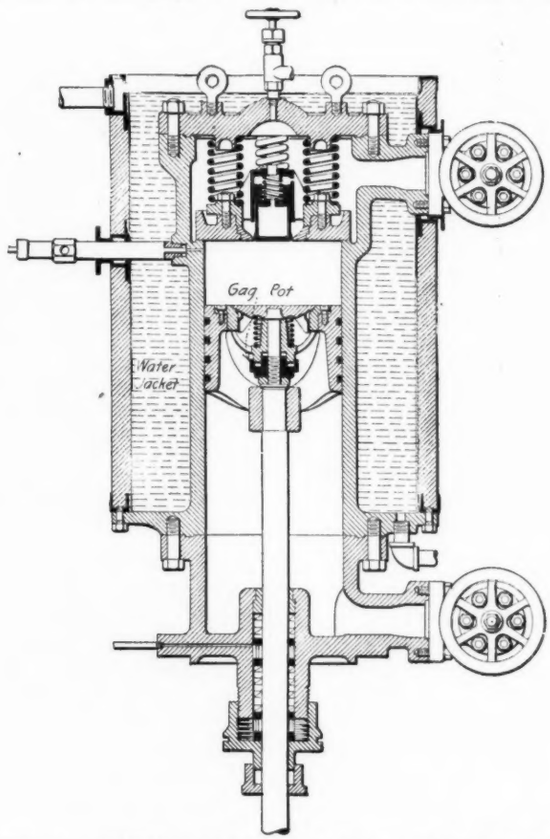


FIG. 11. SECTION OF YORK AMMONIA COMPRESSOR CYLINDER

The suction valve, Fig. 10, is really a part of the piston and is assembled in a cage held in place by countersunk slotted screws *A*. These screws must be a tight fit at the threads and must be set up very tight to prevent their coming loose. The joint between the cage and the piston has no gasket, it being a ground joint. If, from any cause, this joint leaks and a quick repair job is necessary, a gasket of $\frac{1}{32}$-in. pure rubber or thin lead can be used, but the joint must be ground tight.

The lift of the valve, also of the closing cushion, is adjusted by the gagpot arrangement and locknut at the bottom end of the valve stem. The spring should have just sufficient tension to support the weight of the valve.

The safety head on this compressor is not a discharge valve and must not be allowed to act as such. This head forms a ground joint at the top of the cylinder walls and will leak in a short time if the head moves up and down.

If leakage does occur, it will be found quicker and cheaper to insert a boring bar and face the top of the cylinder wall than to grind with emery and oil. A gasket can be used in emergency, but it is not advisable. To make a temporary job, a lead gasket is cut to a good fit and thick iron washers are used under the springs.

*Nos. I and II articles appeared in the May 9 and May 30, 1916, issues.

The most common trouble with this type of compressor, Fig. 10, is caused by the suction-valve cage screws coming loose. This is noticed by a slight pound when the piston passes the top center. The loosened screw will come in contact with the safety head, causing it to lift from its seat. When this slight pound is heard, do not increase the clearance to get rid of it, but lift the head and find the cause.

The discharge valve is contained in a cage fastened in the safety head by capscrews or studs and nuts *B*. A gasket can be used here, but a ground joint is best.

Leakage of the suction valve or of the joint between the suction-valve cage and the piston is first noticed by the frost melting from the suction line and the line becoming quite warm. This heating is caused by the hot gas being allowed to pass from the top to the bottom of the cylinder. A thermometer inserted in the suction line close to the compressor is the best thing I know of to give notice of defective valves. The thermometer will show the increased temperature when there are no other indications of leakage.

Fig. 11 is similar to Fig. 10 in design.

Power-Plant Welding Outfit

By E. S. Fitz

SYNOPSIS—That the field of oxyacetylene welding is rapidly increasing is plainly evidenced by the articles which have appeared recently in the technical press. It seems, however, that the welding outfit is considered too much as an appliance for the use of the repair shop only, instead of as an extremely useful tool for the individual plant. This article indicates otherwise.

While it is true that no novice should attempt to weld the seam of a high-pressure boiler or anything where a poor weld would result in great damage, still any mechanic with a fair modicum of common sense can, in a few lessons, learn to make the numerous repairs that occur around the average factory power plant.

The company by whom I am employed has 35 electric delivery autos. Some six months ago the rear-axle castings on seven of the newest ones developed cracks of such a serious nature that it was feared they would have to be replaced. As these axles are expensive, the thought of scrapping them was not pleasant.

I had been interested in autogenous welding for some time previous to this, but had not become convinced that we had enough work to pay for installing a welder. However, it was certain that if these axle castings could be taken care of in this manner, the machine would pay for itself at once.

Several days were spent in looking over the different makes of machines. The one finally decided on as most suitable to our general purpose was a $120 outfit. One thing that led us to decide in favor of this outfit was that there was a cutting attachment that could be used with the welding torch, while with most other makes a separate and very expensive cutting torch was necessary. The offer of 10 days' free instruction in its shops, which the company makes to purchasers, was also an incentive to buy.

A representative of the company, after looking at one of the axles, said that, as it was a steel casting, it would be a very simple job to repair. He offered to have their welding instructor repair one as a demonstration provided we would agree to purchase a machine if satisfied. This offer was accepted. The next day an axle was taken from its car, the transmission gears were removed, and it was set up on horses in a handy position to work on. Although the casting weighed in the neighborhood of 600 lb., it was considered unnecessary to preheat it, as the material was steel. A No. 11 copper tip was used with the oxygen and acetylene pressures at 30 and 20 lb. respectively. As two of the cracks extended through the flange face at the gear-case opening, it was decided to weld these points first to hold the casting in shape. The torch was adjusted to give its longest flame and applied to the crack at the edge of the flange. In a few seconds the metal at this point became molten and was blown out by the force of the gases issuing from the torch. The torch was then carried farther back and brought slowly forward along the crack, carrying still more of the molten metal before it. This process was continued until a V-shaped notch had been blown out for the full length and practically the full depth of the crack. Only a slight skin was left at the bottom to prevent the metal from running through. This process is known as "blowing-out."

The torch was next turned down considerably, so as to prevent melting through the casting, and the welding stick applied. These sticks are mere slender rods of the same material as the article being welded. The stick was held near to but not touching the V-shaped notch, and the torch flame was carried in small circles over the notch and the end of the stick until both became melted. The stick was then applied to the bottom of the notch and worked forward and backward with a stirring motion, at the same time slowly advancing along the crack. The torch was continued in the circling motion, always slightly leading so as to prepare the metal ahead of the stick. As the casting was rather thick, it was not attempted to fill the crack to the top in one operation; in building up so high some of the melted metal would have been likely to run ahead into a part of the groove that was not melted, thus forming an imperfect weld.

The first trip across filled the notch up about halfway, and the second time it was filled up slightly above the surrounding casting. The other cracks were then welded in the same manner. There was one difference in the handling of the rest of the job. Because of the shape of the casting the other cracks ran slightly uphill toward the gear-case opening. The "blowing-out" process was the same as before, starting at the lowest point. The weld was also started at the lowest point and, as there was no tendency for the metal to run ahead, the notch was filled completely in one operation. This axle had five cracks ranging from 3 to 8 in. in length, yet the whole job was completed in two hours at a cost of about $8 for material.

The next axle I tackled myself, and although it was a hot and rather tiresome job, I found nothing extremely difficult about it, and the car from which the axle came has been in service for four months, without any flaws developing in the weld. The main thing in this, as in many other things, seemed to be the confidence to see it through.

On the next job tackled, however, I found that it was possible to have too much confidence. Two of the stay-bolts in the water jacket on one of the large dough mixers had worked loose and were leaking badly. The proper thing would have been to calk them tight, but in the pride of my new possession I set out to weld them in so that they would never come loose again. I spent one of the most miserable times of my life on that job. The stay-bolt would expand when heated and shove the red-hot sheet out in the form of a great pimple. Then, when cooling after welding, it would contract and nearly pull out. In fact, it pulled so nearly through the first time that calking after that was out of the question. This contraction also would crack the weld, and the leak would be as bad as ever. I welded that thing five times and finally got it tight, but it was a horrible appearing job. Needless to say, I calked the other bolt.

Expansion a Factor

Expansion is one thing that the amateur welder must be particularly careful to allow for. This is especially true in handling iron castings, as this material is weak when hot and easily pulls apart. All welding-machine manufacturers put out booklets dealing with this subject, and if their instructions are faithfully followed, very little trouble will occur. The company from which the outfit was purchased furnishes purchasers with a 130-page bound volume that goes quite deeply and thoroughly into the subject of handling the different metals.

As expected, the welding outfit paid for itself on the auto axles alone. But it has also more than paid for itself in other repairs to the factory machinery. There is scarcely a day when it is not called into use at least once. Also we find it unnecessary to carry such a large stock of repair parts as formerly, for broken parts can generally be repaired in a very short time. At first our broken gear teeth had to be machined after welding. Now we use a material called "vul-carbon" as a mold, and a little dressing up with a file is all that is necessary.

The number of uses to which this very useful tool may be put is surprisingly large.

The dampers on our boilers were not tight, and we wished to fasten plates to fill in the space between the damper and the breeching. It was impossible to use a brace or breast drill, as there was not enough room. So two men spent ten minutes hoisting the welder up into the breeching, and the plates were welded on in no time.

One of the little brass castings on the inlet valve of a toilet flush box was broken. The wholesale house makes a strong kick against selling us plumbing goods. The welder fixed it at a cost of about five cents, time and all.

We were making some ash carts for the ashpits of our boilers. Before the welder came, a man spent two days drilling holes and riveting up one of them. The second one was welded together in one-half day, and the job was much stronger.

I could continue almost indefinitely to tell of the things that have been done with this machine in the past six months. If one has charge of a plant where any considerable number of machine parts get broken, there is the chance for a big saving by installing an acetylene-welding outfit.

Autogenous Machine Welding

By August Ulmann

I would like to call the attention of the readers of *Power* to some experiences that led to the purchase of an autogenous welding apparatus. For the last few years I have been in charge of the construction and organization of a large industrial plant in Cuba in a location remote from cities large enough to furnish the most ordinary facilities for repair work of an emergency character.

From the first a welding outfit was requisitioned, but the principals unwisely could not see the use of spending the necessary money. They were skeptical of the utility of the apparatus because no importing house could be found on the island which would be able to furnish the oxygen required with reliability. The latter difficulty would have compelled the purchase of a number of oxygen tanks in order to import our own supply of oxygen.

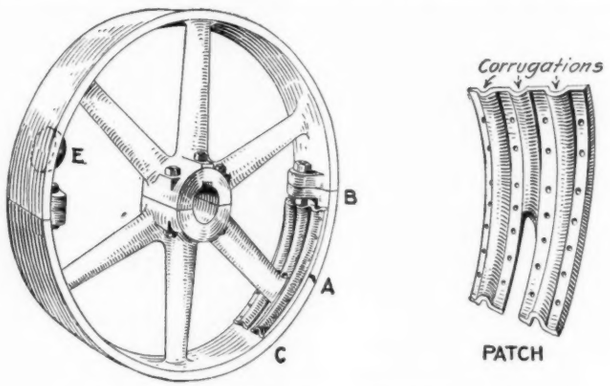


FIG. 1. REPAIR TO RIM OF BROKEN PULLEY

Two breakdowns occurred which could have been repaired with much less loss of time had there been a welding outfit at hand. One was the breakage of a 48 in. diameter cast-iron main-drive pulley that transmitted about 75 hp. at 250 r.p.m. The break was due to the loosening of the rim bolts at *B*, Fig. 1. The bolts dropped out and the piece *AB* was broken out of the rim, luckily remaining in one piece, and but little damage was done to the belt.

As the pulley was light for the power transmitted, in making repairs care had to be taken not to get the patch too heavy. A piece of sheet iron $\frac{3}{32}$ in. thick was selected, and three corrugations were swaged in it while cold, as shown. This was done to strengthen the light plate. Next, the patch was bent to conform to the wheel rim, trimmed and drilled and the rivets prepared. Then the patch and rivets were weighed, and after it was put in place, the rivets being countersunk in the pulley face, a counterweight *E*, equal in weight to the patch *C* and the rivets, was secured on the opposite side of the pulley. The repair was successful.

The plant where the pulley broke was about a half-mile from the main plant, up over a steep hill, which necessitated a detour of nearly two miles for the transportation of any heavy object. An oxcart had to be sent for the pulley, which broke about 8 a.m., and although the greatest exertions were made, it was noon

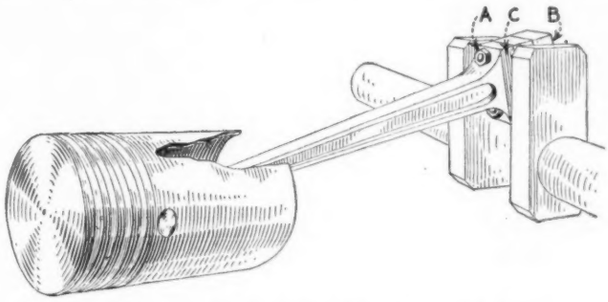


FIG. 2. BROKEN GAS-ENGINE PISTON

when the piece arrived at the machine shop at the main factory. The rest of the day and a good part of the night were required to make the repair, and the pulley was not returned to the plant until 8 a.m. the following morning. This kept the machines idle until noon, making a loss of thirteen hours of production.

Had there been a welding apparatus available, it could have been loaded on the oxcart and taken to the broken pulley and the repair could have been completed during the remainder of the day, and the repaired pulley in place to start the machines at 6 a.m. the following morning, thus saving five hours of production.

The second case was a seriously smashed 20-hp. horizontal gas engine that was used to pump water and run a small dynamo at some distance from the main plant. The accident happened about ten minutes after starting up the engine. The bolt *A*, Fig. 2, failed in the neck of the thread just as the engine was completing the exhaust stroke and commencing the suction stroke. The bearing cap *B* was jerked off, and the connecting-rod was thrown upward so that it landed on the crankpin on the succeeding revolution. At the same time the piston came out of the cylinder and fell into the bottom of the crank-case. The connecting-rod bumped up and down on top of the crankpin until the flywheel came to rest, battering the pin considerably but not beyond repair; as a matter of fact the damage to the engine was comparatively slight. A large piece of the piston was knocked out by the bouncing of the connecting-rod as shown, but the head of the piston and the rings were undamaged. The bearing *C* was broken and had to be recast at a near-by foundry.

The most serious breakage was that of the piston, and as it was impossible to procure a new one (the engine was purchased in Germany), it was shipped to Havana to be welded. It was away fourteen days, and as the remaining parts were repaired and ready in about three days, the machine was idle just eleven days more than was necessary. When the piston did return, the repair was so satisfactory that authorization was immediately given for the purchase of a welding outfit.

After a few months of service the apparatus more than justified itself. Not only did it serve us quickly for many emergency repairs of a minor character, but our scrap pile was also gone over and a great deal of discarded machinery and parts were made useful again—many of them as good as new.

Relays and Their Application

By J. H. Wickman

SYNOPSIS—A review of the various types of relays met with in the operation and control of electric-power circuits and machines. Their fundamental principles, use and connections are explained.

In the earlier days of electric development a relay was usually thought of as a device that worked in conjunction with a telegraph, burglar alarm or signaling system. However, the relay seems to have come into its own and has found a place in the control of almost every kind of an electric circuit and machine. Of the several different kinds of relays that are used in connection with the operation of electrical machinery and auxiliary apparatus, the control-relay is important. It is used most for closing the circuits of solenoid-operated switches and circuit-breakers, this being one of the advantages where remote control is used; that is, the operating switch which closes the circuit through the control relay will handle but a small percentage of current as compared with the relay contacts.

The low-voltage relay is used to trip a motor compensator, an oil switch or a circuit-breaker. In connection with a motor compensator, it may be connected in different ways, the most common and practical method being in connection with an overload relay. Referring to Fig. 1, a general plan of connections, the two series overload trip coils *T* are connected in the main lines from the service and if an overload or low voltage occurs the operation would be as follows: If there is low voltage or no voltage, the plunger, or core *P'* of the low voltage release coil *R* would drop and disconnect the motor from the circuit by tripping the compensator. If an overload is thrown on the motor so as to increase the amperage passing through the series coils *T*, either of the plungers *P* would rise and open the low-voltage circuit at *B*, which in turn would drop the plunger *P'* of the low-voltage release and trip the compensator.

Another way of connecting the low-voltage release is not to use the overload trip coils but to connect the release coil directly across the motor leads; then it would act only if the supply from the generating station was cut off.

When the low-voltage release is used in connection with a circuit-breaker or oil switch, the principle of operation is similar to that just explained. The gravity of the core dropping, when the potential is removed from the coil, opens the compensator, circuit-breaker or oil switch by working some mechanical toggle joint which trips them.

The main principle of the overload relay has been demonstrated in connection with the low-voltage release.

However, in high-voltage alternating current, to simplify the construction and make the apparatus safe for the operator to work around, the operating current is taken from the secondary of a current transformer. By using the secondary current through the relay, the current capacity can be made very small, as most current transformers are designed for a 5-amp. secondary. To allow

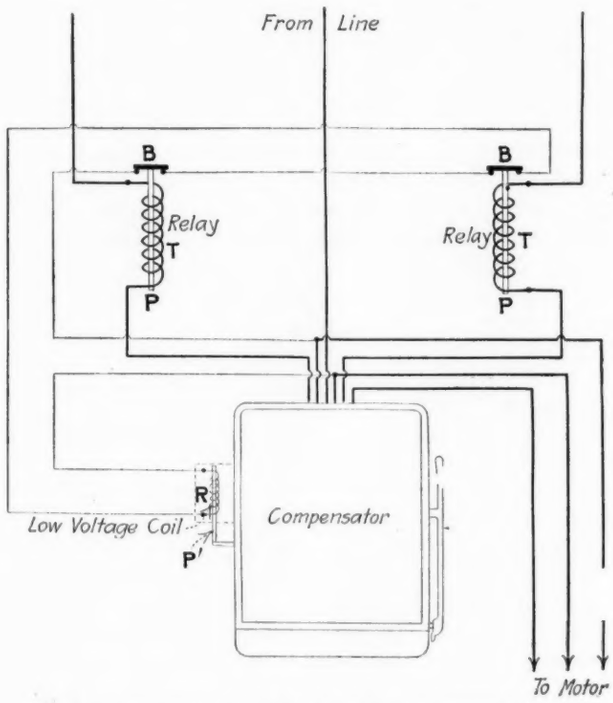


FIG. 1. OVERLOAD RELAYS ON A COMPENSATOR

for 100 per cent. overload, the relay coil would have to be wound for only 10 amp.

Very often overload relays are designed to act after a time interval which prevents instantaneous automatic operation. When several branch circuits or substations are feeding from the main generating or transmission circuits, some selective device must be in the branch circuits to localize or confine trouble so as not to disturb the main supply. At the same time these local or distributing relays, or selectors, must not open on just temporary overloads, but must be set and adjusted to operate in the sequence of their importance. The time interval may be obtained by either an air bellows or air or oil dashpots, all of which are adjustable and may vary the time of operation from instantaneous to 30 sec. If an overload time-limit relay is installed in both main and branch circuits and the main relay is set for a longer time than the branch circuits with a proportional current setting, the branch circuit will trip out ahead of the main circuit.

Reverse-current relays are of two general types, (1) direct-current relays and (2) alternating-current relays. The direct-current reverse-current relay, as its name implies, is used to disconnect rotary converters or direct-current generators from battery-charging circuits should the battery for some reason discharge back into the machines.

Fig. 2 shows schematically a type of direct-current reverse-current relay designed to be mounted on the circuit-breaker stud. It consists of a horseshoe magnet *M* with an armature *A* mounted between its polepieces. The armature carries an arm *a* which is prevented from rotating by the contacts *d* and *c*. The relay is shown mounted on the circuit-breaker stud *C*. The operation is as follows: Assume the stud *C* to be the positive side of the circuit with the current flowing up through the plane of the paper. A magnetic field will be created around the conductor in the direction of the arrowheads on the dotted circles. The horseshoe magnet forms a path of low reluctance, therefore most of the flux will take the path through it as indicated. Current will flow through the armature coil as shown, which will produce a turning effort toward the stationary contact *d*. While the contact arm is held in this position, the circuit-breaker trip-coil circuit is held open. If the direction of the current is reversed in conductor *C*, the flux will be reversed about it, consequently, the polarity of the magnet. This will reverse the torque of the armature, and the contact arm will be thrown over against contact *c*, closing the trip-coil circuit, which in turn will trip the breaker.

It may at first thought seem that if the current is reversed in conductor *C*, Fig. 2, the polarity of the line will be reversed, therefore reversing the direction of the current through the armature coil. Reference to Fig. 3 will show that this is not necessarily true, for it is obvious that the current will be the same direction through coil *a* whether the current is flowing from the generator to the battery or from the battery to the generator.

The alternating-current reverse-load relay is most used at substations fed by parallel transmission lines. It is practicable to have an overload time-limit relay on the generating end of the line and the reverse-current relay at the substation, so that if a ground or a short-circuit occurs on one of the parallel lines, the reverse-load relay will disconnect the defective feeder, and by virtue of the time element at the generating end it will clear itself in

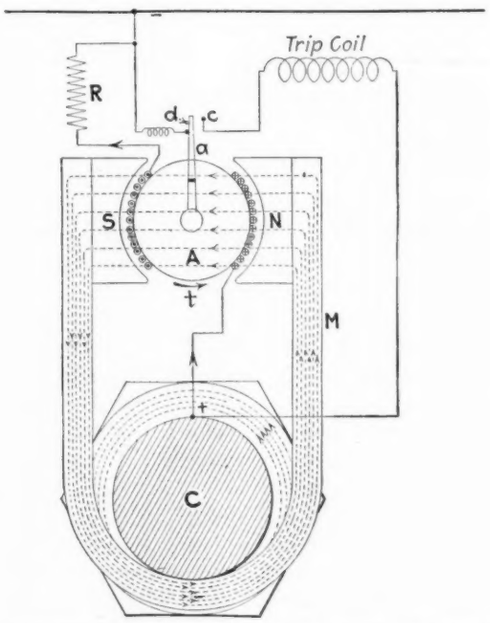


FIG. 2. DIRECT-CURRENT REVERSE-CURRENT RELAY

due course, thus affording continuous service over the other lines.

Alternating-current reverse-load relays are constructed with a series coil *S* and a shunt coil *Sh* on the same core,

as in Figs. 4 and 5. As long as the current flows from the generator to the load, the currents in the relay coils oppose each other, as indicated in Fig. 4, consequently, the relay cannot close. If the current is reversed in the circuit (flows from the load to the generator) as in Fig. 5, the direction of the current in the series coil will be reversed, but will remain the same in the shunt coil. The polarity of both coils is now the same, and their combined pull will close the relay, which closes the trip-coil circuit and trips the switch. Usually on alternating-current circuits the series coil of the relay is connected to the secondary of a series transformer, the shunt coil to the secondary of a potential transformer, and the trip coil of the oil switch to a source of direct current. Fig. 6 shows the connections of this arrangement on a single-phase circuit. One of the conditions under which a reverse load would occur in an alternating-current circuit is shown in Fig. 7. Two feeders *A* and *B* run from the generator bus at the main station to a common bus at the substation. If a short-circuit takes place on feeder *A* at *S*, current will not only flow from the generators to the short-circuit over feeder *A*, but also over feeder *B* to the substation and back to *S*. It will therefore be necessary to open the switch at both ends of Feeder *A* to relieve the trouble on the system. This is accomplished at the substation by a reverse-load relay on switch *a'*. The wire used for winding relay coils may be the regular copper magnet wire, insulated by the common single or double cotton braid, but later designs use enameled wire, which has the advantage that it will withstand a higher temperature and, for the same size wire insulated, occupies less space, thus allowing the size of the relay to be reduced. Little need be said about the care of relays, as about all that could be done is to oil the moving parts once in a while, keep them clean, and not apply voltage much in excess of their rating; good service can then be looked for if properly connected. However, it is well to see that all contacts are tight at each inspection.

The graduations upon the core chamber of relays are usually correct, but where it is necessary to recheck a relay and set the time element, a bank of lamps connected in series with an ammeter and the operating coil has been found convenient. There is no standard rule for the time interval setting. Every operating engineer has to study the conditions that prevail in his particular installation and consider several points, such as the operating capacities of the switches and circuit-breakers, time for switches and circuit-breakers to operate after the operating current has been applied, and variations of time elements themselves caused by weather, dirt, rust and vibrations, etc.

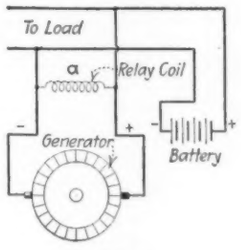


FIG. 3

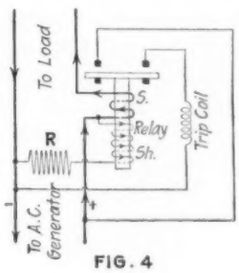


FIG. 4

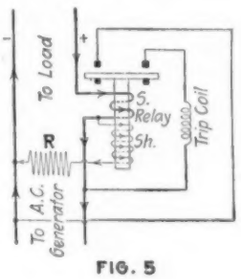


FIG. 5

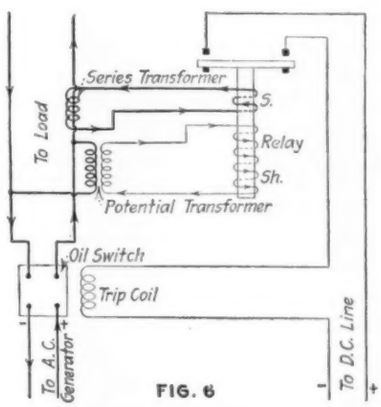


FIG. 6

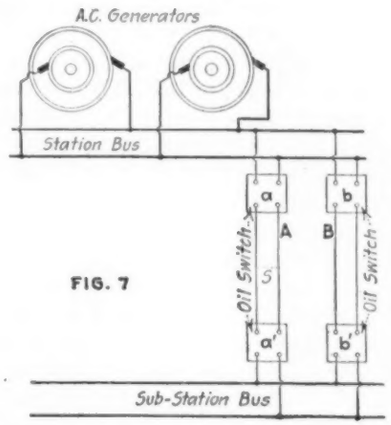


FIG. 7

FIGS. 4 TO 6. REVERSE-LOAD RELAY CONNECTIONS. FIGS. 3 AND 7. SHOW HOW A REVERSE LOAD MAY OCCUR

Given the Velocity, To Find the Height of Fall due to the velocity, square the velocity (in ft. per sec.) and divide by 64.32; the quotient is the height of fall in feet, or expressed as a formula, $h = \frac{V^2}{64.32}$.

JUST FOR FUN

Boiled the Locomotive

A young man was escorting a party through the great locomotive repair shops. In the group was a young lady of a very inquisitive nature. In the course of their march she turned to him and exclaimed:

"Oh, what is that great big thing over there?"

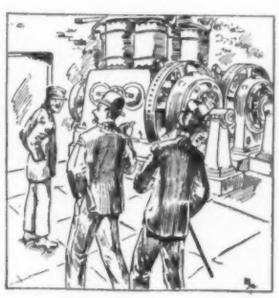
"That's a locomotive boiler," was the reply.

"What do they have to boil a locomotive for?" was the next question.

"Why to make the locomotive tender," he answered without a smile.—Harlan A. Russell, Lawrence, Kan.

Engine Did Not Use Gas

Among the equipment of a power plant were two large vertical Westinghouse engines. They were shut down Sundays. One Sunday a consulting engineer and the chief engineer of a large power plant asked permission to look through the station. As they were leaving, the "consulting engineer," pointing at the idle Westinghouse engines, asked: "How do you run them? With natural or artificial gas?" Both were somewhat surprised when informed that they were steam engines.—D. U. Hartman, Jackson, Mich.



Pressure per Bearing Inch is the total pressure divided by the projected area of the bearing.

European Hydro-Electric Power Development

By Ludwig W. Schmidt

SYNOPSIS—A review of the potential and developed water-powers in European countries; the effect of the war on such development and the possibilities for American capital and engineering.

One of the results of the war in Europe has been a restriction in the supply of coal to the neutral countries, Switzerland, Sweden, Norway and Denmark having suffered heavily under this limitation. It is therefore logical that they have shown more than usual interest in hydro-electric development, and since the outbreak of the war several large hydro-electric power plants have been completed and a number of other projects taken up with a view to relieving the situation.

Europe draws her hydro-electric energy from four principal centers. The most important of these is the Alps, the outlets from which are utilized by Switzerland, Italy, France, Austria and Germany. Switzerland, according to statistics recently published, has 794 water-power plants producing over 20 hp. each, and 6,005 producing less. These plants combined are able to supply about 900,000 hp., and it is estimated that the whole water-power resources of the republic amount to about 2,225,000 hp.

While Germany draws a large part of her hydro-electric energy from the waters coming from the Alps, the conditions for their utilization are not always the same, owing to the geological structure of the ground. It seems that in southern Germany much water is lost because of the porosity of the ground. Nevertheless, in this part of Germany there is available about 600,000 water horsepower. With the accumulation of water drawn into the rivers of the lower parts of Germany and the addition of several other rivers the available maximum increases, and a fairly close estimate of the water-power resources in Prussia, drawn partly from the Alps and partly from the mountainous districts in eastern Europe, shows the following:

Oder River	205,000 hp. medium	82,000 hp. minimum
Elbe River	262,000 hp. medium	98,000 hp. minimum
Weser River	288,000 hp. medium	103,000 hp. minimum
Rhine River	990,000 hp. medium	297,000 hp. minimum
Maas River	64,000 hp. medium	19,000 hp. minimum

Of this amount 446,000 hp. is utilized. A report made to the Minister of the Interior, from which these figures were taken, gives additional data on present steam power in Prussia, of which there is 7,528,000 hp.

Austria and France both take their share of the water power from the Alps, but Italy especially has relieved the conditions imposed by her own shortage of coal by a steadily increasing recourse to water power. In southern Italy, however, spoilation of the timber on the mountains has taken away the natural collectors of humidity, although reforesting has now been undertaken. As it is, Italy has water-power resources amounting to about 5,500,000 hp., of which only one-fifth has been utilized.

Pussia some time ago made an investigation of her available power supply, very little of which is now utilized with the exception of the Ural region. With the report of the commission now in hand it is expected that Russia will soon give more attention to hydro-electric enterprise than in the past.

Another center offering great possibilities is the Pyrenees. The peculiar structure of this mountain range seems to favor the Spanish rather than the French side.

The most promising section for hydro-electric development in northern Europe, however, is in Sweden and Norway. Geographic and economic conditions have worked together to create in these countries about the same ideal conditions as in Italy. While Italy seems to be inclined to split her hydro-power into a large number of smaller enterprises, Norway and Sweden are utilizing the available power in bulk and even exporting it. Sweden was able to extend her power facilities from 760,000 hp. in 1914 to 915,000 hp. in 1915. As the existing power has been estimated between 300,000 to 400,000 hp., there is still plenty of room for development. One of the largest hydro-electric enterprises in Sweden is that belonging to the Government at Trölhattan. This plant at present supplies 80,000 hp., but can be extended to 120,000 hp. The government also owns the plant at Alfkarleby, which will supply 45,000 hp., and a plant in Porjuss, supplying 50,000 hp. A large plant that was not completed when the last returns were made is the Untra hydro-electric development belonging to the municipality of Stockholm for the supply of 45,000 hp.

Development After the War

All the schemes put forward for a governmental or sectional monopoly of electric-power supply in Germany seem to incline more to the utilization of peat for steam generation. So it seems that as far as Germany is concerned the period following the war will see no exceptional development in the use of hydro-electric power. The same will apply more or less to Austria, while in Hungary the conditions may be somewhat different. Whichever way this development proceeds, however, it is fairly certain that both countries will use their own financial means for carrying out enterprises of national interest.

There are indications that the United States will assist financially in the rebuilding of Europe after the war, and it is not unlikely that this will include hydro-electric development. Spain and Italy may offer a useful field for American engineers and financiers. Furthermore, there are the Balkan States with their great possibilities. The future of that part of Europe of course will depend largely upon the outcome of the war and the terms of peace arranged. If conditions in the Balkans remain very much as they have been, foreign capital may be disinclined to risk too much, but it is very likely that, together with the general clean-up of European affairs, ways and means may be found to secure lasting peace in the Balkan States also. The ideal field for American investment and engineering enterprise in Europe, however, may be Russia. Seen from the point of view of hydro-electric enterprise, Russia has the advantage of being industrially still a young country, the power generation being young enough to follow new ways without hurting vested interests.

Editorials

Vocational Study is Urged by Educators

One of the subjects receiving considerable attention at the convention of the National Educational Association held in New York City during the week ending July 8, which was attended by thousands of teachers from all parts of the country, was "The Necessity for Vocational Training."

One of the speakers, Doctor Joyner, termed it "the preparation of the great industrial masses, constituting 90 per cent. of the population of the United States, for their life work. With this there must be developed a sense of obligation and a desire and determination to use increased efficiency to *give* more as well as to *get* more. The dominant aim of education should be preparation for the patriotic performance of duties and the obligations of citizenship through the acquisition of knowledge and the cultivation of the virtues demanded therefor."

It seems passing strange to anyone who has had opportunity to observe, that the value of vocational training, when it is thorough and complete, should be questioned. Vocational training, however, does not mean half training but complete training. The great difficulty in the past has been that vocational training has been considered a sort of side line that may be acquired in a few short weeks and that the pupil should then be competent to go out into the shop, factory or power plant and do the work as well as those who have spent years in acquiring skill and knowledge of the trade. The training is good as far as it goes, but too much should not be expected in a short time and more time should be allowed to acquire proficiency. The term "vocational training," therefore, as loosely applied is entirely a misnomer and may be limited to a few weeks' attendance at a school of indifferent quality and conducted for revenue only. To dignify any such performance with the name of vocational training, even "training" of any kind in a useful pursuit, is obviously misleading and therefore dishonest. It is on a par with the various get-rich-quick schemes.

First and foremost, the instructors in such short-course institutions should be men who are capable of imbuing their pupils with the high ideals that are so necessary to success in any calling, and greater effort must be put forth along these lines in such schools than in those having a course extending over four to six years, because of the short period during which such influence is exerted. If the habit or capacity for thinking connectedly and clearly along any line is acquired early in life, a long step has been taken toward success, and without such capacity there can be little hope of large success. In the short time usually allotted to so-called vocational training there is little hope of supplying the pupil with a complete working knowledge of any branch. All that can be hoped for is to help him to know where such information as he may need can be obtained and how to apply it.

Let there be more and still more effort along that line so that it will be worthy of the name training.

Massachusetts Rules and the A. S. M. E. Boiler Code

Massachusetts was the first of the United States to adopt a standard to which boilers must conform in order to receive the approval that the law requires. Other administrations have adopted regulations patterned more or less closely after those of Massachusetts. The American Society of Mechanical Engineers, recognizing the necessity of uniformity in such requirements, appointed, in 1911, a committee, comprising representatives of the various interests involved, to formulate such a code.

Elihu Root said, in addressing the body convened to revise the Constitution of New York State, "It is no impeachment to a man's honesty, his integrity, that he thinks the methods that he is familiar with and in which he is engaged are all right. But you cannot make any improvement in this world without overriding the satisfaction that men have in the things as they are, and of which they are a contented and successful part."

The Boiler Code Committee found that it had a complicated problem to deal with. Its decision would affect the interests not only of the makers and users of steam boilers, but of everybody who made anything that went with them or who, like the insurance companies, were concerned with their safety. Thousands of copies of its tentative report were printed and distributed to everybody who had expert knowledge of, or interests affected by, the subject. Innumerable hearings were held, an advisory committee was appointed to assist the original committee in matters of detail, and a report was finally evolved which met the approval of the council of the society and received its formal sanction in February of last year.

This report embodies the best counsel and the expert advice of the foremost authorities in the country, modified to meet the contentions of the interests affected, while still safeguarding the public safety.

It is now a question of getting it universally adopted; but Massachusetts will have none of it.

The differences between the Massachusetts Rules and the A. S. M. E. Code were pointed out in detail in an article published in *Power* for Apr. 18, by Stanley P. Stewart. If these differences could be discussed in a high-toned, judicial, professional way upon a purely engineering basis by representatives of both bodies, and personal animosities and commercial considerations kept out of the consideration, there would be no difficulty in agreeing upon the requisites of reasonable safety. Natural laws know no political divisions or geographical bounds. A boiler that is safe in Texas is safe in Massachusetts. Unprejudiced engineers could make a code compliance with which would produce a boiler that, with proper treatment, would be safe anywhere.

But there is to consider the man who has in good faith invested his money in boilers supposedly safe but not built in accordance with the latest views as to the best practice. On account of numerous failures of lap-seam

joints the boiler of that type has fallen very much into disfavor. Massachusetts, which has suffered several disastrous explosions from this cause, has prohibited their further installation and has succeeded in establishing and requiring a factor of safety of five for the most favored of those now in use, with drops of allowable pressure with continued use which will soon make the lap-seam boiler obsolete in that commonwealth.

On the other hand, there are in the West many lap-seam boilers operating with a factor of safety of four. To raise this to five would be to decrease the allowable working pressure twenty per cent., which would amount in many cases to confiscation. With the stress that has been put upon the danger of the lap-seam joint and the improved methods that have been evolved of inspecting it, it is not likely that with rigorous attention many of these boilers would explode during a process of gradual amortization. The A. S. M. E. Code therefore, while it prohibits the installation of any more lap-seam boilers, allows those already in use a pressure based upon a factor of safety of four, with a reduction of pressure with increasing age, so that in time the lap-seam boiler under its provisions would also become distinct.

But Massachusetts, by its early start, has got ahead of the Code in this respect, and it would be unreasonable to expect her to take the retrogressive step of letting her more rigid requirements down to meet it.

Perhaps it would have been better for the Mechanical Engineers' committee to have confined its attention to new work; to have furnished the directions for building boilers that would comply with the best known principles of design, out of the material best adapted to the purpose, or at least boilers that should be safe so far as material, design, construction and installation are concerned, and allow the different states and municipalities to adopt this as a standard for future installations and to treat existing conditions each in its own way. This would certainly be true if many were in the condition of Massachusetts. The compromise between engineering ideals and commercial conditions suggested by the code committee is, however, the result of much investigation and discussion and offers to states that are tardily about to undertake boiler regulation a basis upon which the quality of the boilers in use may be gradually raised without hardship to anybody and with a diminution of the present danger of explosion.

Of the desirability for uniformity there is no question, but the need for that uniformity is more urgent with respect to new than to old work—to boilers about to be installed than to those which are already in use. Whatever differences there may be in local conditions as to existing boilers, there can be no engineering differences as to new ones. Why cannot the Massachusetts Board of Boiler Rules meet and confer with a subcommittee of the Boiler Code Committee of the American Society of Mechanical Engineers, discuss the differences between the Rules and the Code as to new boilers on an engineering basis, and both adopt what is best from that point of view? Then if it grates upon the susceptibilities of the Massachusetts Board to adopt the A. S. M. E. Code, it need not be urged to do so, for a boiler built by the Code will conform to the Rules and be as good in Massachusetts as in any other state. And this is the real desideratum—that the code or rules governing new work be the same everywhere.

Influence of Pipe Covering

Frequently one finds the covering of pipe lines, receivers, boilers, heaters and similar equipment in steam and refrigerating plants in a condition so dilapidated as to warrant one in believing the engineers in charge wholly unappreciative of the value of good insulation. Oftentimes, where a repair job has necessitated the stripping of piping or apparatus of its covering, the bare places will be left so for weeks and perhaps months, notwithstanding the resulting drain on the plant's economy. Pipe lines are covered to accomplish either of two things—to keep heat units from getting out, as in the case of a steam or hot-water line, or to keep heat units from getting in, as in refrigerating or cold-water lines. To insulate apparatus or piping so as to completely realize either of these purposes is of course impossible, but negligence in this respect means an inexcusable loss to the establishment.

If one half the heat generated in a boiler furnace goes into the water inside the boiler while the other half goes out partly with the chimney gases and partly by radiation, then for each heat unit that travels from the boiler to an engine cylinder or other place of utility, two heat units are given up by the fuel on the grate. Conservation of the coal pile, reduced to a thermic basis, will therefore proceed in the ratio of two to one for every heat unit that the insulation of the pipe surface keeps from getting away. Again, suppose the efficiency of the boiler reaches seventy-five per cent. Then one and one-third heat-units will be saved on the grate for each heat unit which the insulation of the piping keeps from escaping, the saving effected being in each case inversely proportional to the boiler efficiency. Thus the condition of the pipe covering has a considerable bearing for good or ill upon the fuel supply.

But the condition of the insulation influences the economy of operation in still other ways. The percentage of moisture in the steam passing to an engine cylinder is, for example, largely dependent upon the thoroughness of the pipe covering. The nearer the insulation of the supply line approaches perfection the dryer the steam, hence the smaller the evaporation required per horsepower developed. Also, the dryer the steam the more nearly it approximates the properties of a perfect gas and the more nearly its expansion conforms to the perfect curve. The value of well-kept insulation in augmenting the horsepower output is therefore apparent.

Because the last-named benefits affect the fuel account indirectly, they are often lost sight of in appraising the virtue of insulation. Inasmuch as the theoretical value of a plant's insulation is generally figured on a basis of the saving directly accruing from arresting the escape of heat units, the items mentioned easily explain why the results of actual tests often show higher economy than do the theoretical calculations.

Do you bind or file *Power*? If so you need an index. You can have it for the asking. It is ready now for the first half of 1916.

We have been waiting expectantly for some hydro-electric enthusiasts to attack H. G. Stott's statement that the steam turbine can outperform the water-power plant on load factors of less than fifty per cent.

Correspondence

Viscosity in Cylinder Oils

The comment of F. L. Fairbanks in the May 16 issue on my letter in the Apr. 11 issue, on oil viscosity, is one of the most intelligent articles on the subject of steam-cylinder lubricants and steam-cylinder valve lubrication that have ever been published. It shows that the author is experienced and a master of the subject. That letter, together with C. P. Poole's comment in the June 20 issue, seems to extend generally into the subject of lubricants and lubrication, and is not confined particularly to the subject of viscosity. I accept cheerfully the extended scope of the argument, because after all, what we want is not only truth, but as much truth as is possible under the circumstances.

Mr. Fairbanks' article, boiled down, states that the viscosity of cylinder oils, when taken comparatively at the temperature of use, is of value and that under certain conditions of operation, owing to the excessive weight of the piston, no oil has the power to come between metallic surfaces and substitute what Mr. Fairbanks calls "liquid friction" for "metallic friction."

Mr. Fairbanks admits that animal oils lose viscosity rapidly above 300 deg. F. He also states that the oil which lubricates valves best is a mineral or mineral compounded oil and shows a retention of viscosity above 450 deg. F.

Viscosity, according to the dictionary, means "stickiness"; but when I discuss viscosity as applied to cylinder oils, I do not refer to the dictionary definition or to any other definition or application of the word different from that which is generally applied to it in the oil trade. When one says a cylinder oil has a certain viscosity, he means that it has that viscosity at 212 deg. F., not at operating temperatures.

It is an extremely difficult undertaking to take the viscosity at temperatures above 212 deg. While I have no evidence of the instruments that were used to take Mr. Fairbanks' test, I must confess from a long experience in the use of such instruments that I lack confidence in the accuracy of the test. That the readers may have the truth and appreciate how much prejudiced I am, if I am prejudiced, and give Mr. Fairbanks the fullest credit for correctness, allow me to explain briefly just what viscosity is, as generally understood in the trade. This explanation is best accomplished by a short description of the Sayboldt instrument.

I describe the Sayboldt instrument, not because I believe it is the best, but because it is the instrument adopted as a standard by the Standard Oil Co., which produces more than one-half of the cylinder oils. It is the standard instrument of the trade, with which all other instruments are compared. This instrument has a steam-jacketed copper reservoir, at the bottom of which oil is run out of a faucet of given size. The oil is heated to 212 deg. F. and remains at that temperature for 15 min., the bulb of the thermometer being inserted in the oil halfway down. The faucet is then opened and the oil allowed to flow out. The number of seconds required for 60 c.c. to flow out of the viscosimeter indicates the viscosity of the oil. In other words, viscosity of cylinder oils, as it is understood in the trade, means the number of seconds it requires 60 c.c. to flow from the viscosimeter.

I think every reader will agree with me that there is nothing in this physical test that reproduces the physical conditions under which the cylinder oil is to lubricate.

It does not demonstrate the power of the oil to vaporize. It does not demonstrate the comparative power of the oil to hold its place under extreme pressure. It does not demonstrate the power of the oil to adhere to wet surfaces; and as Mr. Fairbanks says, it does not even demonstrate the viscosity of the oil at temperatures of use. Therefore, I think that Mr. Fairbanks' article is more apt to confuse the average engineer than my article, for, you understand, Mr. Fairbanks suggests that my original article might tend to confuse.

Mr. Fairbanks has introduced a new and comparatively unknown and unused sort of viscosity. He admits that viscosity at 212 deg. F., which is the standard viscosity, is not reliable, and he introduces viscosity at higher temperatures, which the average engineer has no opportunity of ascertaining, which the man who sells cylinder oil does not use and which, so far as I know, has been comparatively little investigated by authorities. I would have to see the instrument and have to operate it before I would be convinced that viscosities at higher temperatures are any more reliable than those at 212 deg. F.

In taking the viscosity of the oil in the Sayboldt apparatus or any other constructed with a similar tap faucet it will make a difference of as high as 20 points if the window happens to be open near the instrument and a draft blows on the faucet. If the room itself is cold or if a fan is blowing on the instrument, the flow of oil is retarded.

I have constructed viscosimeters of numerous designs for taking the viscosity at the higher temperatures, and these devices have produced some surprising results, but the most surprising was the lack of uniformity of tests made with the same oil under seemingly the same conditions.

Those cylinder oils well known and generally accepted by the profession as being of the highest grade are not of the highest viscosity and will not show the highest viscosity even if the viscosity is taken at the temperature of use.

Some of the best cylinder oils are not only low in viscosity, but are about the lowest in viscosity as well as in flash tests of any cylinder oil generally sold and having a reputation for quality.

Mr. Fairbanks admits that animal oils rapidly lose comparative viscosity at higher temperatures than 212 deg. F., but I hardly think that Mr. Fairbanks will deny what engineers the world over are generally agreed upon—namely, that the best cylinder lubricant for a

locomotive pulling a heavy load upgrade is tallow. He refers to the tallow pot that he carried on his locomotive for the purpose of lubricating the Westinghouse driver brake, and he probably knows what most engineers know—that when they come to a grade and have a heavy load, it is a common habit for them to steal the driver-brake tallow for the locomotive cylinder. Yet we all know that the viscosity of tallow is comparatively insignificant and low at the temperature of use. The reason Mr. Fairbanks gives for stopping the use of tallow on the driver brake is the trouble caused by the free fatty acids developed thereby, and that is the only reason why its use has been abandoned in steam cylinders generally.

My company[1] was the first, and for four years practically the only one selling mineral cylinder oils. It has never pretended that mineral oil surpasses tallow in its power to reduce friction between the lubricated parts.

We feel that we are going the limit when we claim equal or nearly as good lubrication.

Our works are located on the line of a railroad, and it is nothing unusual for engineers connected with this road to buy tallow with their own money. They keep the tallow upon their engines for emergency for certain high spots on the road, upon which they may be compelled to make time.

Lubrication is lubrication, whether it is 500 deg. above or 50 deg. below zero.

We do not have to go into the steam cylinder to prove that comparative viscosity is not indicative of lubricating qualities. It is a matter of record, which the New England Cotton Manufacturers Association minutes will show, that just as the cotton manufacturers have reduced the viscosity of spindle oils, so they have been enabled to operate more spindles per horsepower, until today most of the mills demand in their spindle oils the least possible viscosity consistent with a safe flash test.

For general line shafting a mineral lubricating oil never showed any better lubricating properties than sperm oil, and yet sperm oil is of low viscosity as compared with the mineral oils, and this is true at temperatures of use. Mineral oil has been preferred to sperm, largely because it lacks gum, has ability to cleanse itself, easily filters, has a lower first cost and is not liable to develop free acid and thus destroy the metal of the bearing.

The lubrication of high-speed electric generators and electric motors, as well as the lubrication of automobiles, has been perfected, not as the viscosity of the lubricants has been increased, but on the contrary, as the viscosity has been decreased and the rapidity of the feed increased.

Mr. Fairbanks refers to metallic friction and liquid friction, but the reader must realize that there are metallic friction, liquid friction and metallic-liquid friction. In other words, there is not only friction between the molecules of the liquid itself, but between the metal and the liquid. A series of experiments has shown that as viscosity increased, the metallic-liquid friction increased.

To express another thought, I would call attention to the fact that there are some varieties of petroleum tar which, because they are subjected to superheat in the still and have driven off everything in the way of lighter products, will retain their viscosity at higher temperatures better than any cylinder oils known. Yet when these tars are introduced into a cylinder as a lubricant, they will not adhere to the surfaces, but tend to roll themselves into small balls. If high viscosity at the temperature of use means power to lubricate, why not use tar? The reason we do not use tar is not because it possesses or does not possess viscosity. It is because it will not answer the purpose.

Mr. Poole writes as follows: "The statement to the effect that the viscosity of a cylinder oil bears no relation to its lubricating quality has been made many times—mostly by persons interested in the exploitation of cylinder lubricants composed largely of animal oils."

I deny empathically that this is true or to any extent partly true. I have made this statement since Professor Sayboldt first introduced his viscosimeter. I made this statement in an address before Stevens Institute over a quarter of a century ago, when animal cylinder-oil lubricants were comparatively unknown. I made this statement in a treatise on the subject of steam-cylinder lubrication published in the January, 1905, *Power*. This statement has been largely and generally made by the manufacturers of the high-grade, low-viscosity mineral cylinder oils to which I herein refer. When you take into consideration that manufacturers of such cylinder oils are concerns with exclusively quality trade, the unfairness of Mr. Poole's accusation is self-apparent and likely to be misleading.

I deny that any experienced oil chemists understand "that the staying quality of a cylinder oil decreases with increasing specific gravity, unless the inherent viscosity also increases."

Mr. Poole does state truthfully that oleate of aluminum can give an artificial viscosity to a cylinder oil.

If viscosity is viscosity, what difference does it make how the oil gets it? There are methods of giving artificial viscosity to a cylinder oil which cannot be detected in any laboratory. By giving artificial viscosity to a cylinder oil I mean altering the viscosity after the oil has left the still or the filter.

I wonder if Mr. Poole will deny that a cylinder oil is improved in its lubricating properties by filtration, that this improvement is generally acknowledged and is as thoroughly a universal fact as is the fact that steel possesses far greater durability than cast iron. Yet you reduce the viscosity of cylinder oil in the process of filtration, not only the viscosity at 212 deg., but the viscosity at temperatures of use.

It is my contention that inasmuch as it is the function of a lubricant to come between the lubricated parts in a film and prevent the metal from coming in contact and present in itself the least frictional resistance, the lubricant which will do that best is not necessarily the lubricant with the least viscosity or the one with the most viscosity. It is the lubricant which will do it, and "the proof of the pudding is the eating thereof."

Take any normal type of engine running under normal conditions; take off the cylinder head and examine the conditions of the interior of the cylinder as to the amount of lubricant on the walls of the cylinder. Then run the engine for one week on a lubricant which I shall submit and which we will call *X*, using the same amount as was used of the previous lubricant, practically using only half of the quantity of *X*. At the end of another week, again take off the cylinder head, and I warrant that

[1] E. F. Houghton & Co.

there will be a greater deposit of *X* lubricant on the walls of the cylinder than of the previous lubricant, provided, of course, the previous lubricant is any of the well-known cylinder oils.

This is a commonsense test, the kind that appeals to the competent engineer. It does not include anything so delicate as the viscosity test at temperatures of use, because there are not in existence any standard instruments for making such tests.

CHARLES E. CARPENTER.

Philadelphia, Penn.

Action of Air in Surface Condensers

In the interesting and valuable article by C. F. Hirshfeld entitled "Action of Air in Surface Condensers," in the Feb. 29, 1916, issue of *Power,* I am unable to see the logic in the argument by which he attempts to prove that the temperature in the condenser must necessarily be decreased as the fluid makes its way from the turbine exhaust nozzle toward the air-pump suction in order that the necessary changes in the mixture of steam and air may be accommodated—in other words, the argument that he makes concerning the ideal condenser illustrated by the diagrammatic sketch, Fig. 5, of the article referred to above.

Of course, the temperature in an actual condenser does decrease as the fluid flow progresses from the turbine exhaust nozzle toward the air-pump suction, but this is not the point in question, and is to be accounted for on other grounds. I do not see from the argument why the progressive condensation of the steam cannot occur at constant temperatures in such an apparatus as that diagrammatically indicated by Mr. Hirshfeld's Fig. 5, the richness of the mixture of air with steam progressively increasing as the air pump suction is approached, but the mixture remaining at constant temperature.

To me it seems perfectly easy to conceive of such condensation occurring at constant temperature, and it is equally easy to make curves of the properties of the mixture of steam and air based on Dalton's law, upon the saturation pressure of steam at the given temperature, and upon the gas content equation of air.

Williamsburg, N. Y. H. L. H. SMITH.

Some Dynamo Experiences

A well-known gas-tractor company formerly used the tractors in the power plant. They were belted to shunt-wound dynamos which were operated in parallel. This plant was described in the Feb. 16, 1915, issue of *Power.* A number of interesting experiences were encountered there.

One old Card 220-volt compound dynamo with the series field cut out never did commutate properly. The sparking was severe, and the commutator was soon badly but evenly blackened and pitted. It was turned down and polished a number of times without any gain in operation. Then the mica was undercut, but this did not help, and so the series winding was cut in with a low resistance shunt across its terminals. Conditions did not change in the least, and after working with the old machine for some time, the electricians gave it up and it was replaced.

The general opinion was that the trouble came from the vibration and jar caused by the heavy two-ply belt running over the 11-in. pulley. This made the comparatively light armature run about 1,200 r.p.m., and of course the hit-and-miss governed engines jerked it some. One electrician insisted that the machine was overloaded. This could not be told, for the rating on the name-plate was not to be relied on, as the machine had been through several sales.

One morning when we were starting up, a ring of blue fire circled the end of the armature of another machine that was running. The engine men were alarmed and shut the machine down, though there were no indications that anything was damaged. When the foreman of the power house arrived, he looked the dynamo over and could find no damage; it was then started again and ran well. A little later one of the electricians found a lot of small pieces of wire about the machine. Further investigation showed that the outer armature band had slipped off and shorted the brush rigging. The dynamo was run for several days before a new band was put on.

An interesting time occurred one evening when the load was heavy. For some reason one engine quit working. This of course caused the dynamo to motor at once, which added to the load on the other machines, and the voltage began to drop. For some reason the dynamo that was motoring speeded up. It all happened so quickly that the switchboard man lost his head, and instead of pulling the switch on the motoring dynamo, he tried to raise the voltage by turning up the rheostats on the other generators. This added to the speed of the motoring machine, which was dangerous. Fortunately the circuit-breakers opened. One of the electricians came and pulled out the main-load switch, and in a short time the dynamos were cut in and the excitement was over.

One night the power went off entirely owing to engine trouble. The wiring arrangement was a three-wire system with a balancer set. This set stopped, of course, and as the men were anxious to get the power on again, they closed the main switch to the load without starting the balancer. Since the lights were also on the three-wire system, it is not hard to tell the result. If I remember correctly, four arc lamps and about one hundred incandescents were burned up on the side of the three-wire system with the smaller load. I understand that the balancer set is equipped at present with an automatic starter to prevent such trouble.

One of the dynamos was fitted with a paper pulley. We noticed that the crown was wearing off, but because the load was quite heavy and the electricians were very busy, the pulley was not removed and put in order. In time the edges were nearly as high as the center, and one day when a sudden overload caused the belt to slip a trifle, it slid onto the high inner edge and was badly damaged by rubbing against the dynamo frame.

The dynamo was needed so badly that we arranged a crude stand or rest for a turning tool, another belt was put on and the tractor engine was started. One man with a bar held the belt well over on the pulley, while another turned off the ridges at the edges. This method was dangerous but quite satisfactory, for one could easily tell by the run of the belt when the pulley was in shape. From that time on the pulleys on all dynamos were trued whenever it seemed advisable with the engine run-

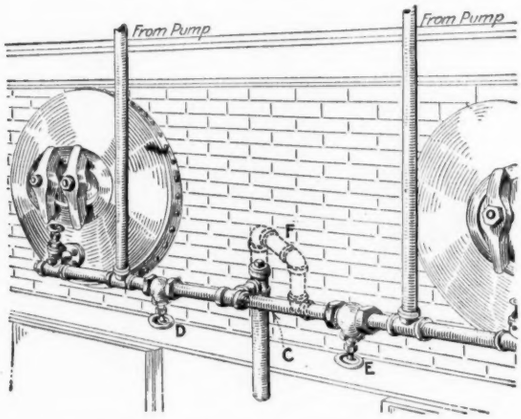
ning. It was a bit careless perhaps, but it saved time and trouble and did away with pulling the pulleys.

After a time the company installed slow-speed modern machines to take the place of the old ones, which had been put in during an unexpected demand for power. The later machines were fitted with cast-iron pulleys of good size. At that I think most of the trouble with the older machines was due to carelessness or ignorance.

Charles City, Iowa. C. V. HULL.

Rigid Feed-Pipe Connection

Two boilers were supplied by a pump with an injector as reserve, but the line went from one drumhead valve to the other with no allowance for expansion. Valves *D* and



FEED-PIPE CONNECTIONS TO BOILERS

E controlled the feed to the boilers. A crack was found in the body of valve *D* and the piping had to be rearranged as shown dotted at *F* and the section *C* left out; it has since given no trouble. The failure was undoubtedly the result of expansion strains and shows that even for short pipes and moderate temperature variation (in this case about 10 ft. and 200 deg. F.) allowance for expansion is necessary. MORRIS ELLISON.

Washington, D. C.

What Distorted the Valves?

Every unusual incident that occurs in the power plant has a cause, though sometimes it is hard to find. The following is one incident:

In a neighboring plant there are two simple Corliss engines. One was shut down at midnight. At 5 a.m. it was started up, and the engineer was surprised at a pound that developed in the head end of the cylinder. He found that the latch would not hook on the head-end steam valve. The engine was stopped, and the back bonnet of the head-end steam valve was removed and eyebolts were screwed into the valve, but it could not be pulled out. The front bonnet was then taken off and the valve driven out. Its condition showed sufficient lubrication; it was not rusted, but was badly distorted. The engineer got busy with a file and scraper and succeeded in trimming the valve down so that it could work freely in its seat.

A few mornings later the same thing occurred again in the same engine, but this time it was the crank-end steam valve. The valve was not distorted as badly as the head end had been. The engineer, not caring again to tackle the valve with a file and scraper, called in a machinist who turned the valve down in a lathe—unfortunately more than it ought to have been, with the result that it was too small. The affair winded up with a call for help to the makers of the engine. A man arrived and decided that the valve seats had to be rebored and new valves fitted. This with other minor work that was necessary to be done on the engine, will make a repair bill in the neighborhood of $900. The erecting engineer did not enlighten the engineer in charge as to what was the cause of the trouble.

What caused first the head-end and after that the crank-end admission valves to become distorted after a shutdown of only a few hours? What precautions are necessary so that it will not occur again?

New York City. G. T. MICHAELS.

Reversal of Exciter Fields

A rather unusual incident occurred in connection with a 60-volt two-pole exciter supplying a two-phase inductor-type alternator which was run in parallel with a number of others to supply a transmission line, the nearest one of which was about four miles away. One evening the frequency suddenly dropped from 60 to 55 and the lights began to flicker. Not much attention was paid to the occurrence at the time, as it was thought to be due to trouble on the line.

The exciter was used to charge a storage battery, and the next morning when the charge was begun it was found that the current was going into the battery in the wrong direction. The leads were then crossed, which sent the current through in the proper direction. A few days later the same incident occurred again and the same thing happened in regard to the storage battery. This time an investigation was made, and the exciter brushes were found to be badly gummed up and not making good contact. The reversal of the exciter polarity was explained as follows:

With an exciter supplying the field circuit, as in Fig. 1, the current divides at *A*, a small part flowing through its own fields, as at *B*, and the rest through the fields of the alternator, as at *C*, then back to the negative brush of the exciter. If the brushes at *D* become dirty or

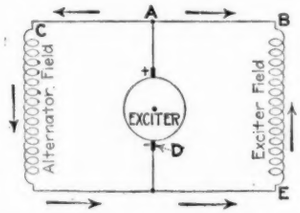


FIG. 1. SHOWING HOW FIELD WAS REVERSED

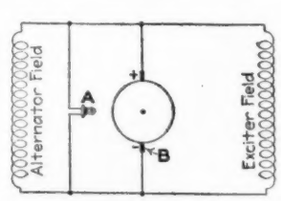


FIG. 2. LAMP USED TO SHOW REVERSAL

gummed up so as to lose contact or are lifted from the commutator, the circuit will be open, and the self-inductance of the alternator fields tends to keep the current flowing in the same direction through the circuit. As the circuit is open at *D*, the current continues to flow around through the exciter fields, as at *E*. This e.m.f. of self-induction exists only while the current is dying down, but may be of sufficient strength and of sufficient duration to overcome that of the exciter and reverse the residual magnetism of its fields.

The experiment can be tried of putting a lamp across the circuit, as at *A*, Fig. 2. The rated voltage of the lamp should be about twice that of the exciter. Then by lifting the brushes at *B*, it will be found that the instant the brushes are lifted off the commutator, the light tends to die down, but the e.m.f. of self-induction in the alternator fields takes effect and the light instantly increases to more than what it was when getting current from the exciter, but lasts only for a moment and then dies down. If a voltmeter which indicates positive and negative is put across the exciter leads when it starts generating again, the polarity will be found reversed. It would not be advisable to try the experiment, however, until the alternator is running alone and without any load. Neither would it be advisable to try it very often, as the self-induced e.m.f. might be high enough to puncture the insulation.

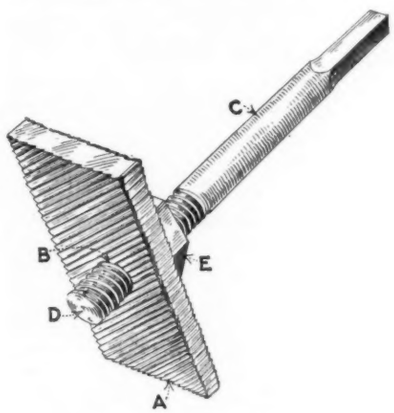
LEON L. POLLARD.

Fairfield, Me.

Facing Up Pump Valve Seats

In truing up the valve seats of pumps, etc., when no grinding outfit is at hand, the following method has proved of great value:

Anneal a flat file and cut a piece *A* long enough to cover fully the seat of the valve to be ground. Drill and tap a hole *B* in the center for a ⅜-in. bolt, then reheat and temper it. Cut the head off a ⅜-in. bolt *C*, 4 to 6 in. long. Run the bolt down through piece *A* and extend it through ¼ to ⅜ in. to form a guide to steady the grinder when in use. A locknut set up tight holds the cutter fast to the stem, which is squared at the opposite end. By placing it in a brace or breast drill a nice job can be quickly done.



TOOL FOR TRUING UP BRASS VALVE SEATS

Dwight, Ill.

CHARLES BERGMARK.

Synchronizing Alternators

The following method of paralleling alternating-current generators is used by me and may be of interest to the readers of *Power*. One thing that always puzzled me was when to give the signal to the switchboard attendant, so that the minimum effort would be required for the synchronizing of the machines. No matter when the signal was given, the incoming machine would be either too fast or too slow; then it meant throttling it down or giving it more steam.

In this plant there are three alternating-current three-phase 2,300-volt generators—one 250-kw. noncondensing and two 400-kw. noncondensing machines. The two 400-kw. machines synchronize with little trouble. As soon as the governor has picked up the speed, the signal is given and the engines are very nearly in step; if a little out of the way, they can be adjusted by the by-pass. But in synchronizing the 250-kw. machine with either of the 400-kw. units, the operation was a little more difficult. If one did not catch the two machines just right after the signal was given, there would be considerable manipulating of the throttle before they could be synchronized, especially if the load was coming on. One night, after some time was spent in getting the incoming machine in step, I happened to glance at the receiver gage and noticed that it registered about 4½ lb. pressure just as the operator closed the oil switch. This suggested a way of telling when to give the signal to the operator.

It was found that with steam pressure at normal, 4½ lb. pressure on the receiver gage is a pretty good sign that the incoming machine is running at synchronous speed. It is not necessary, however, to wait until the receiver gage shows the exact pressure; as soon as the gage shows about 1½ lb. pressure when the small machine is to take the load, the signal is given to the switchboard attendant, and while he is making his adjustments at the switchboard, the pressure can be brought up to the desired point or as near it as possible.

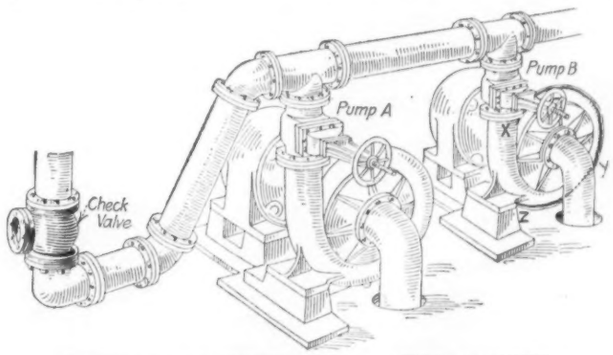
By the foregoing means I have had good results, and it is very seldom that the needle on the synchronoscope makes more than a few revolutions in either direction. The majority of times the needle shows that the two machines are nearly in step; in fact, after the synchronizing plugs are placed in their respective places, the needle makes barely one revolution, and many times, owing to ideal load and steam conditions, the needle on the synchronoscope does not move from its neutral position, thus showing that the two machines are in perfect synchronism.

THOMAS M. GRAY.

Middletown, N. Y.

Water-Hammer in the Discharge Line

In a plant where I am employed we had trouble with water-hammer in the centrifugal pump *B*, shown in the illustration, when its discharge valve was accidently left open while pump *A* was running. When shutting *A* down there would be an awful jar on *B*, but the same effect was not produced with *A* standing idle and shutting *B* down. Both pumps are directly driven by motors, and the starting boxes have low-voltage release and are on the same circuit.



PUMP CASING BURSTED BY WATER-HAMMER

Pump *A* is of 1,500 and *B* 1,000 gal. per min. capacity, and both discharge through a 10-in. pipe to a tank about

70 ft. from the pumps and 50 ft. above the ground. Both suction pipes are extended 22 ft. into the well and are bolted to I-beams. The water in the well is sometimes 12 ft. from the top.

We have had two accidents. The first happened when there was an overload, and the pump switch "kicked" out at the switchboard, causing *A* to stop. When pump *B* was examined, it was found that the casing was cracked from *x* to *z* along the dotted line shown. The second accident happened under similar conditions, just after a new casing had been put in place, but this time it cracked only as far as *y*. It was then decided to put a check valve in the discharge-pipe line, and this stops all jarring even if the discharge valve is left open.

Antioch, Calif. GUS A. JOHNSON.

Replenishing a Torch Wick

The illustration shows a simple method of inserting a new wick in a "self-contained lighting plant"—a hand torch. A single strand of the wick from a ball is put in through the spout and passed out at the top of the

DRAWING NEW WICK INTO TORCH SPOUT

torch and tied, as shown, forming a circle. After drawing the circle around until the proper number of strands are secured, the whole wick is cut at the spout and the end pushed into the torch through the top.

Toledo, Ohio. J. H. CUNNINGHAM.

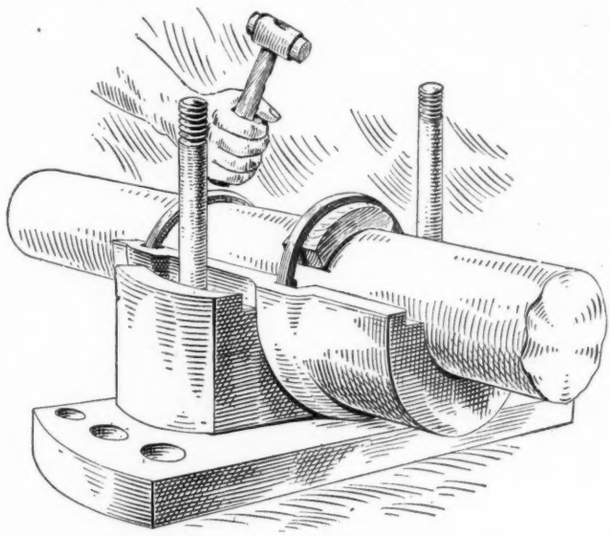
The Loud-Speaking Telephone

The loud-speaking telephone can be made useful in connection with power-house and switchboard duty, where continuity of service is important. The adjustments can be made in the amplifier and receiver to produce a loud and distinct sound. Moreover, where telephone circuits run parallel to high-tension transmission lines, the induction and electrostatic discharges interfere with the safe operation, and at times it would be dangerous to handle the ordinary telephone receiver, especially when storms are due. For hours before the storm may reach the vicinity of the line, the lightning discharges are very severe, although every precaution may be exercised in the way of transformers, vacuum arresters, horn gaps and other protective devices tending to minimize the electrostatic disturbances. W. J. TRUESDELL.

Parlin, N. J.

Truing up Oil Rings

It is sometimes found that an oil ring is a little out of round and fails to turn properly. The ring may have been damaged slightly in assembling the machine or jammed or struck subsequently. In some machines the oil rings can be easily removed, but in others, particularly in the intermediate bearing of a three-bearing machine,



HARDWOOD BLOCK UNDER RING

considerable work is required. A simple method is here suggested for truing a ring in place. By calipering one of the true oil rings, the correct inside diameter is obtained, and calipering the shaft at the bearing gives its diameter. Then by sawing out a hardwood form to fit the curvature of each and using as shown, the ring may be tapped with a copper hammer and revolved slowly and made true in a short time. GORDON FOX.

Evanston, Ill.

Hot-Bearing Treatment

Nearly every engineer has a favorite treatment for hot bearings by the use of a variety of substances—mine is cocoanut oil. I have used this oil on boxes that were dangerously hot, and it is remarkable what it will do toward "holding" them. It is far ahead of anything I know of, especially on bronze or brass bearings. A little is all that is needed generally, and it is not expensive.

In tropical countries cocoanut oil is in a liquid form, but in a cooler climate it solidifies somewhat and must be heated a little. In one case an engine with a main bearing so hot that a shutdown seemed inevitable was kept running for three hours without doing damage to the bearing. In several other cases, as in heavy sugar machinery and the like, this oil has given excellent results. One of the points in its favor is that the bearing does not have to be opened up and cleaned to get rid of the substance used, as in the case of some of the "heroic" treatments. F. E. WOOD.

St. Louis, Mo.

Running Condensing requires such change in the valve setting as will secure earlier closing of the exhaust valves of the low-pressure cylinder, so as to obtain the same cushioning effect from compression of exhaust steam of lower pressure.

Inquiries of General Interest

Single-Phase and Three-Phase Alternators in Parallel—Is it possible to operate a single-phase alternator in parallel with one phase of a three-phase machine? J. E. B.

Yes, this would be possible if both machines are operated at the same voltage and frequency, but it would be bad practice, if for no other reason than that it would be found difficult to maintain a proper distribution of the load.

Ammonia Asphyxiation—How would you treat a person suffering from ammonia asphyxiation? A. M.

Call a doctor; get the patient into the open air; swab the eyes and face with a strong solution of water and ordinary vinegar; apply artificial respiration manually or with a pulmotor. The patient should freely sip a solution of vinegar and water if he feels very ill after being revived to consciousness.

Engineers' Licenses in Philadelphia—Do engineers and firemen require a license to operate in Philadelphia, Penn.? H. J. M.

Yes. Applicants for engineers' and firemen's licenses must be 21 years old, and the licenses are renewable yearly without examination. The cost is $3 for each license and $1 for each renewal. A fine of $100 is imposed on owners for placing a nonlicensed man in charge of a high-pressure boiler.

Direction of Movement in Valve Setting—In valve setting should an engine be turned forward or backward? J. R.

During all the operations of valve setting, the engine and valve gear should be moved in the direction in which the engine is intended to run, so that the lost motion or backlash may be taken up in the right way. If the engine or the valve gear is moved too far, it should be brought to the correct position by completing the forward rotation of the shaft or turned back well beyond the desired point and again brought up to that point with a motion in the right direction.

Second-Hand Condensers for Absorption Plant—We desire to use the condensers and coolers formerly used in a compression system on an absorption system and one engineer questions their use. What are the objections? J. M. C.

The parts of an absorption system, particularly the condensers and coolers, must be very clean to insure good service. Condensers and coils from a compression plant will be heavily coated with oil, interfering materially with the heat transfer. If necessary, use the condenser and coils, but arrange to boil out the oil by means of a strong soda solution or sweep the oil out by blowing high-pressure steam through the coils.

Replacing Boiler Blowoff Flange—How would a leaky blowoff flange be removed from a boiler; and would a new flange have to be set in place with hot rivets? C. A. N.

The old flange would have to be removed by cutting off the rivets that hold it to the boiler, either by chipping or by an oxyacetylene torch. The new flange should be carefully fitted to the shape of the boiler and have the rivet holes marked off from the holes in the boiler shell and, before the new flange is set, it should be lightly tapped for the screwed end of the blowoff pipe. The new flange then should be firmly bolted to its place and secured by hot rivets, so that upon cooling and shrinkage of the rivets, it will be drawn tight to the boiler and may be calked tight with a round-nosed tool. After the flange has been set and calked, the tapping to receive the pipe screw should receive a finishing cut.

Rectification in Absorption Systems—What is the purpose of a rectifier on an absorption system, and how does its operation affect the efficiency and capacity of the system? H. R. L.

The rectifier ordinarily consists of water-cooled coils that receive the ammonia and water vapors which pass through the analyzer from the generator. Its purpose is to condense the water or aqueous vapor from the ammonia gas. The less effective the rectifier the more water vapor goes through the system, and consequently the less the capacity for a given quantity of ammonia gas circulated, which of course means inefficiency. At full capacity under ordinarily poor conditions, not more than 8 per cent. water vapor should be carried past the rectifier. Rectification must not be carried so far as to condense the ammonia gas, for this would be a complete loss.

Current-Limiting Reactances—When large three-phase star-connected alternators are operated in parallel and the neutral is grounded through a suitable ohmic resistance, why is it advisable to place reactance in the generator leads? N. A. C.

The ohmic resistance limits the current to ground only in case of a ground occurring on one cable. With a short-circuit between two of the phases, the current flowing in the short will not flow through the ground resistance, and therefore would be limited only by the impedance of the generator windings and cables. By the use of reactance in the generator leads, the initial flow will be limited and the mechanical and potential strain on the generator and system will be materially reduced. The use of current-limiting reactances is not confined to the generator leads; they may be used in the feeders or between the bus sections.

Transformers for Light and Power Load—Where lighting and power are in the same installation, the power two-phase, three-wire, 240-volt; the lighting three-wire, 120-240-volt, is it practicable to increase the capacity of one of the transformers by that required by the lighting system above the power capacity and run the lighting circuit from this transformer? B. A. B.

This arrangement is feasible, but when the motors are started, if they are of large size, they may cause the lamps to fluctuate. There also may be a slight unbalancing of the voltage, as it is rarely that two transformers of different size will have the same voltage regulation. Better practice would be to install a separate transformer for the lighting or divide the lighting on each of the two phases by increasing the size of each transformer one-half the required capacity of the lighting system.

Required Diameter of Steam Pipe—What should be the diameter of a steam pipe for furnishing a continuous flow of 6,000 lb. of steam per hour at 90 lb. gage pressure and a velocity of 7,000 ft. per min.? S. M. S.

The specific volume, or number of cubic feet per pound, of dry saturated steam at 90 lb. gage, or 105 lb. absolute, is 4.23 cu.ft., and the volume of 6,000 lb. of steam per hour would be equivalent to $\frac{6,000}{60} \times 4.23 = 423$ cu.ft. per min. To convey this volume at a velocity of 7,000 ft. per min., the cross-sectional area of the pipe would need to be $423 \div 7,000 = 0.06042$ sq.ft., or $0.06042 \times 144 = 8.7$ sq.in. Hence the actual diameter would be $\sqrt{\frac{8.7}{0.7854}} = 3.328$ in., and the nearest commercial size of pipe would be 3½-in.

Height of Suction Lift Below Sea Level—How high could water be lifted by suction of a pump at a depth or elevation of 1 mi. below sea level? M. C. H.

When water is raised by suction, the actual operation consists in the creation of a vacuum in the pump, and the water is raised up into the pump barrel by the pressure of the atmosphere acting on the free surface of the suction water. At sea level and at ordinary temperatures the pressure of the atmosphere is equivalent to the pressure of about 30 in. of mercury, or 33.97 ft. of water, and the pressure increases with the depth of a shaft by about 1 in. rise of the barometer for each 900 ft. descent below sea level. Hence for a descent of 1 mi. the increase would amount to $5,280 \div 900 = 5.86$ in. of mercury, and as 1 in. of mercury pressure equals 1.132 ft. of water-column pressure, there would be $1.132 \times 5.86 = 6.63$ ft. more of water column balanced by the pressure of the atmosphere than at sea level, or a total height of $33.97 + 6.63 = 40.6$ ft. of water column. This is the theoretical height to which the water could be raised by the suction pump if there was a perfect vacuum in the suction chamber, no air leakage and no loss of pressure from pipe friction. In practice it is seldom possible to obtain over about 80 per cent. of the theoretical lift, and the probable lift would be about 32.5 ft.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Fractional Distillation of Lubricating Oils*

By J. G. O'Neill†

SYNOPSIS—The different oils that are compounded to make a commercial lubricating oil; that is, the "fractional" parts of the oil are distilled off by being heated with superheated steam, and each fraction is tested for viscosity, specific gravity, flash and fire points.

The object of this investigation was to devise a fractional-distillation method for separating a mineral lubricating oil into its component light, intermediate and heavy oils and to investigate the properties of these oils. Such a method had to meet the following requirements: It must not decompose any of the component oils; by reuniting the component oils the original compounded oil should be obtained without appreciable change in its physical properties; double fractionation should not decompose any of the oils or appreciably change their physical properties; the method must give concordant results with the same oils; it must be a laboratory method capable of operation in a reasonable length of time and without danger to the operator; the fractions of an oil must be of sufficient number and of volume great enough to allow the determination of their physical properties.

The investigation of the properties of these fractions of oils should yield: Accurate information of the quality of mineral oils used to compound the original oil; should show the presence of undesirable light or heavy oils and the quantity present; should enable us to forecast the relative stability of oils when used in the service; should give us data which would clearly point out to us the most logical path to be taken to improve the quality of lubricating oils, thereby increasing the life of the oil when in use and decreasing engine troubles arising from the use of inferior oil; should show the different properties of asphalt and paraffin-base oil fractions in the relation between viscosity, flash point, specific gravity and volatility; should point the way to future research work in lubricating oils.

The literature on the testing of lubricating oils gave no assistance or information on the fractional distillation of these oils. In selecting a method four possible modes of procedure were considered. They were: Fractionally distilling and condensing the oil under vacuum. Fractionally distilling by the aid of heat and heated inert gases. Fractionally distilling by the aid of heat and violent agitation of the oil. Fractionally distilling by the aid of heat and superheated steam.

When an oil or liquid is placed in a flask, a vacuum created and heat applied, it is found that the oil or liquid will vaporize at a much lower temperature than it would if the vacuum did not exist. It has been found that the oils constituting lubricating oils will distill without decomposition under the foregoing conditions. A United States patent was granted the Vacuum Oil Co., of Rochester, N. Y., on this process. This method was not considered a feasible laboratory method for the reason that unless the condensation of the oil vapors was perfect, some of the lighter oils would be lost; also, because it was desired to work with glassware to closely watch the distillation. Distilling in glassware under a high vacuum was considered too dangerous for a routine laboratory method.

The procedure of this method consists of heating inert gases such as carbon dioxide or nitrogen to about 380 deg. F. and conducting them into the oil heated to about the same temperature. It has been found that the oil will then distill 250 F. below its ordinary distilling temperature and without decomposition. This process is covered by U. S. Pat. 848,903, Art of Distilling, granted to Heinrich Hirzel, of Leipzig-Plagwitz, Germany. He explains his process in full on page 2, lines 85 to 107, of U. S. Pat. 848,903. This process was tried out in the laboratory of this station using heated carbon dioxide, and as far as the distillation was concerned it was found to do all the inventor claimed for it; but it was found impossible to entirely condense the oil vapors mixed with the inert gas, and the method had to be abandoned. The resistance of oil vapors to condensation when mixed with inert gases, and also the greatly reduced temperature at which oil vaporizes when exposed to inert gases, are worthy of note.

No reference in any literature could be found which treated of this procedure for distilling lubricating oil. Several years ago I performed some simple experiments in which I mixed a light oil with a heavy petroleum oil, and on heating the mixture in a flask which was violently agitated, it was found that the light oil distilled off at much lower temperature than it would have done if not agitated. The apparatus required for using this method in the test would be too complicated, but it is here noted to show that in all probability, when oil is used as a lubricant and violently agitated, conditions arise which greatly increase its volatility.

After considerable experimentation, in which the construction and size of each part of the apparatus were changed several times, a successful method using heat and superheated steam was evolved. This method is considered to be especially applicable for the purpose of this test, since the process of distilling lubricating oils with superheated steam is practiced by a large number of lubricating-oil manufacturers.

The fractional distillation apparatus consisted of a steam boiler, steam superheater, oil still and water condenser, connected and fitted with thermometers.

Of the oil to be tested 540 grams was weighed in the round-bottomed flask of the oil still and the apparatus connected. The gas burners under the steam boiler and oil still were turned on and lighted. The electric heater was turned on at low heat. When steam was generated in the boiler, the heater was turned on full and the superheated steam allowed to escape through the bypass between the superheater and the oil still until the steam showed colorless and until the oil in the still reached a temperature of about 380 F. When a colorless, steady stream of steam issued from the bypass and the oil was at a temperature of about 380 F., the bypass was closed and the steam forced through the hot oil in the still. The temperature of the superheated steam and the oil was now slowly raised, the rate of heating being governed by the rapidity with which the oil volatilized. Both of these temperatures were found to be easily regulated. The volatilized oil and steam from the still first entered the air con-

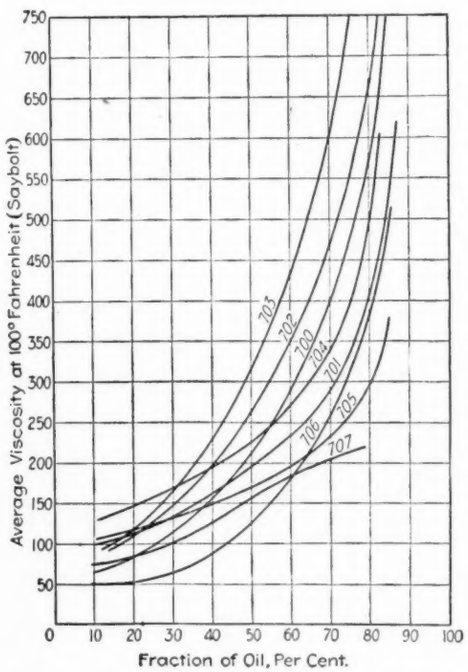


FIG. 1. SHOWING THAT VISCOSITY OF AN OIL IS THE AVERAGE OF VISCOSITIES OF ALL ITS COMPONENTS

*From the May "Journal" of the American Society of Naval Engineers.

†Chemist, U. S. Naval Experiment Station, Annapolis, Md.

denser, and the vapors which passed through the air condenser were all condensed in the water condenser. Approximately three-quarters of the distilled oil was recovered in the receiver of the air condenser; the remaining quarter was recovered in the separatory funnel of the water condenser.

The oil was divided by this method into usually four or five fractions, one fraction always remaining as a residue oil in

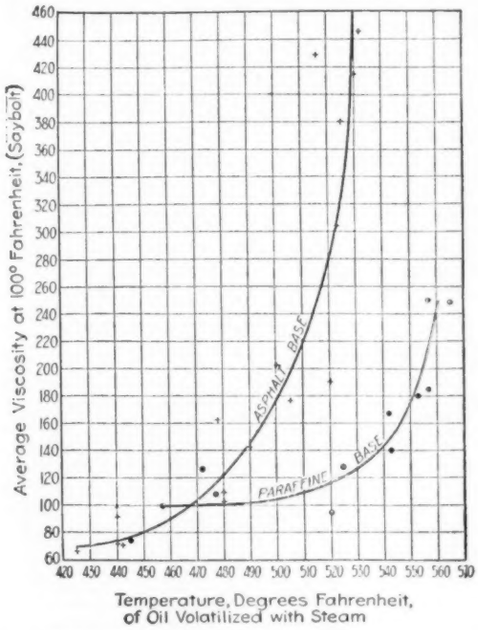

Average Viscosity at 100° Fahrenheit, (Saybolt)
ASPHALT BASE
PARAFFINE BASE
Temperature, Degrees Fahrenheit, of Oil Volatilized with Steam

FIG. 2. VISCOSITY AND VOLATILIZATION OF ASPHALT AND PARAFFIN BASE OIL

the glass flask of the oil still. The fractions were made as nearly equal in weight as possible under the conditions; they were then dried in a desiccator over calcium chloride or sulphuric acid until clear and free from moisture. The heating of the oil still was uniform throughout, as shown by the

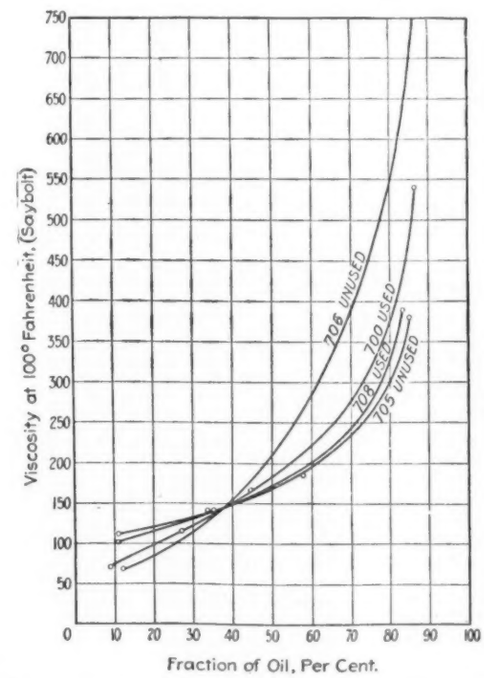


FIG. 3. VISCOSITY OF USED AND UNUSED OILS

slight difference in temperature between the oil in the still and the vapors leaving the still. In fractionally distilling a lubricating oil the following data were taken: Temperature of steam, oil and vapor at the beginning of the distillation of each fraction; temperature of steam, oil and vapor at the end of the distillation of each fraction; time required to distill each fraction; quantity of water condensed with each fraction; weight of each fraction. All temperatures were expressed in degrees Fahrenheit, and no correction was made for exposed stem.

All lubricating oils used in this test were obtained from the oils laboratory and had been previously received for station investigation. They were representative samples of oils used in the service and all of them are on the acceptable list for use in the Navy. They were all straight mineral oils with the following classification and origin:

Laboratory No.	Classified As	Base
700	Light forced-feed oil	Asphalt
701	Medium forced-feed oil	Paraffin
702	Medium forced-feed oil	Asphalt
703	Medium forced-feed oil	Asphalt
704	Medium forced-feed oil	Paraffin
705	Light forced-feed oil	Paraffin
706	Ice-machine oil	Asphalt
707	Ice-machine oil	Paraffin

Name of Oil / No.	Fraction	Per Cent. of Total by Weight	Time Taken to Distill Min.	Temperature of Distillation, Degrees F. Beginning Steam	Beginning Oil	Beginning Vapor	End Steam	End Oil	End Vapor	Cu. of Water Condensed
(1) 700	A	17.38	45	390	390	380	500	480	470	280
	B	22.32	24	500	480	470	510	500	490	175
	C	20.10	25	510	500	490	530	524	510	185
	D	22.78	30	530	524	510	550	540	522	275
	E	17.42	Residue oil.							
(2) 700	A	19.14	35	390	390	380	500	480	470	250
	B	19.70	20	500	480	470	510	500	490	155
	C	18.34	20	510	500	490	540	530	520	160
	D	19.00	25	540	530	520	550	540	530	200
	E	23.82	Residue oil.							
(3) 701	A	18.31	60	420	410	400	530	530	415	400
	B	18.38	35	530	530	515	560	554	530	225
	C	18.49	40	560	554	530	585	580	550	250
	D	19.64	33	585	580	550	605	600	564	300
	E	25.18	Residue oil.							
(4) 701	A	23.68	75	440	440	420	535	530	512	415
	B	43.06	85	535	530	512	600	600	566	475
	C	33.26	Residue oil.							
(5) 702	A	27.23	55	390	380	370	520	515	510	460
	B	24.17	25	520	510	515	550	535	525	180
	C	28.39	45	550	535	525	560	550	535	350
	D	20.21	Residue oil.							
(6) 703	A	24.39	50	400	390	380	500	500	500	400
	B	22.30	35	500	500	500	530	525	525	225
	C	24.81	30	530	525	525	550	545	540	250
	D	24.50	Residue oil.							
(7) 703	A	23.44	60	410	400	400	510	500	495	400
	B	23.13	45	510	500	495	530	523	518	275
	C	25.93	30	530	523	518	550	545	540	250
	D	27.50	Residue oil.							
(8) 704	A	22.48	65	405	400	400	540	545	545	475
	B	22.27	20	540	545	545	550	565	562	200
	C	20.97	25	550	565	562	580	580	568	200
	D	34.28	Residue oil.							
(9) 704	A	21.82	35	450	445	440	540	542	545	375
	B	19.54	25	540	542	545	560	565	560	185
	C	24.63	40	560	565	560	580	570	580	250
	D	34.01	Residue oil.							
(10) 706	A	21.29	55	380	375	370	430	423	430	400
	B	23.07	35	430	423	430	480	475	465	225
	C	25.71	25	480	475	465	515	500	490	350
	D	29.93	Residue oil.							
(11) 707	A	19.76	60	390	380	380	515	515	510	425
	B	18.42	30	515	515	510	520	530	525	200
	C	20.15	25	520	530	525	545	545	540	225
	D	41.67	Residue oil.							
(12) 700, unused U. S. S. "Arkansas"	A	24.00	55	390	385	385	480	475	470	325
	B	24.96	30	480	475	470	510	510	505	250
	C	27.57	35	510	510	505	550	550	540	300
	D	23.47	Residue oil.							
(13) 700, Used, filtered U. S. S. "Arkansas"	A	17.44	45	385	380	380	470	475	468	350
	B	18.40	30	470	475	468	500	503	490	250
	C	17.66	25	500	503	490	535	530	516	215
	D	20.44	35	535	530	516	560	545	530	300
	E	26.06	Residue oil.							
(14) 705, Unused U. S. S. "Arkansas"	A	21.95	45	425	420	420	545	545	535	450
	B	24.23	40	545	545	535	560	562	552	250
	C	22.83	40	560	562	552	585	575	562	275
	D	30.99	Residue oil.							
(15) 705, Used, filtered U. S. S. "Arkansas"	A	21.20	45	415	400	390	540	540	525	400
	B	22.32	20	540	540	525	565	568	550	300
	C	23.28	25	565	568	550	585	585	560	300
	D	33.20	Residue oil.							

The oils were fractionally distilled, giving the following results: Run No. 2 was a duplication of run No. 1; run No. 4 was a duplication of run No. 3; run No. 7 was a sample of No. 703 oil which had been fractioned as in No. 6; the fractions were then reunited and the recombined oil was refractioned; run No. 9 was a run similar to run No. 7, but using No. 704 oil; run No. 12 was a sample of unused No. 700 oil from U. S. S. "Arkansas"; run No. 13 was a sample of used filtered No. 700 oil from U. S. S. "Arkansas," which had been in the system 100 hours; run No. 14 was a sample of unused No. 705 from U. S. S. "Arkansas"; run No. 15 was a sample of used

filtered No. 705 oil from U. S. S. "Arkansas," which had been in the system 100 hours.

After the distillation all of the oil fractions had a slightly acrid odor except A, No. 706. This fraction had a strong kerosene odor, which did not disappear on long standing in the laboratory. The slightly acrid odor of the other fractions of oils disappeared in a few days.

The first fractions distilled from the various lubricating oils were mobile and of a light-yellow color, similar to a "spindle" oil. There was a gradual increase in viscosity and depth of color, with increase of the distilling temperature of the fractions of an oil, and in all cases the residue had a dark appearance, much resembling a dark cylinder oil. In no residue-oil fraction was there any solid matter deposited.

The viscosity, flash point, firepoint and specific gravity of the original oil and its fractions were determined by the oils laboratory under the supervision of Lieut. J. L. Kauffman. Viscosity was determined at 100 F. in a Saybolt universal viscosimeter; flash and fire points in the Pensky-Martin closed-cup apparatus; and specific gravity was determined by a pycnometer at 15.6 deg. C. For convenience of reference the item "per cent. of total" is repeated in the following tabulation. The name and number of the oil, the name of the fraction and the explanations given apply to the following oils and fractions of oils:

Name and Number of Oil	Name of Fraction	Per Cent. of Total	Viscosity at 100 F.	Flash Point, Deg. F.	Fire Point, Deg. F.	Specific Gravity
(1) 700	Original oil	.....	199.0	312	364	0.937
	A	17.38	64.8	273	300	0.917
	B	22.32	108.5	328	362	0.930
	C	20.10	202.4	360	408	0.937
	D	22.78	428.5	408	458	0.942
	E	17.42	2,581.0	404	440	0.949
(2) 700, duplicated	A	19.14	64.8	266	310	0.9179
	B	19.70	101.8	287	345	0.929
	C	18.34	177.3	348	400	0.936
	D	19.00	380.0	374	408	0.9415
	E	23.82	1,726.0	407	440	0.9466
(3) 701	Original oil	.....	205.0	395	455	0.887
	A	18.31	99.6	326	360	0.8767
	B	18.38	128.0	390	414	0.8803
	C	18.49	164.0	388	405	0.8827
	D	19.64	250.3	388	412	0.8911
	E	25.18	619.8	453	486	0.9005
(4) 701, duplicated	A	23.68	102.6	338	364	0.878
	B	43.06	165.5	400	435	0.884
	C	33.26	511.9	448	475	0.898
(5) 702	Original oil	.....	275.0	354	392	0.933
	A	27.23	91.2	316	338	0.925
	B	24.17	190.0	372	398	0.930
	C	28.39	414.0	390	405	0.935
	D	20.21	2,358.0	404	446	0.943
(6) 703	Original oil	.....	316.0	348	384	0.925
	A	24.39	98.1	305	328	0.915
	B	22.30	197.2	358	383	0.922
	C	24.81	445.0	392	430	0.927
	D	28.50	1,402.0	438	450	0.933
(7) 703	Fractioned*					
	A	23.44	85.7	310	344	0.915
	B	23.13	183.8	360	414	0.921
	C	25.93	448.0	386	406	0.932
	D	27.50	1,557.0	406	470	0.9324
(8) 704	Original oil	.....	255.0	410	436	0.904
	A	22.48	126.2	338	362	0.896
	B	22.27	179.2	407	435	0.900
	C	20.97	248.0	427	442	0.904
	D	34.28	603.0	444	468	0.9138
(9) 704	Fractioned*					
	A	21.82	123.2	358	420	0.8965
	B	19.54	171.8	384	438	0.8977
	C	24.63	236.2	426	455	0.9043
	D	34.01	641.0	438	488	0.9131
(10) 706, ice machine	Original oil	.....	105.0	278	318	0.929
	A	21.29	51.3	252	274	0.9078
	B	23.07	70.0	278	312	0.9190
	C	25.71	160.6	348	364	0.9280
	D	29.93	516.5	368	398	0.9353
(11) 707, ice machine	Original oil	.....	128.0	373	401	0.872
	A	19.76	73.6	316	342	0.8659
	B	18.42	94.2	362	394	0.8695
	C	20.15	168.5	372	404	0.8732
	D	41.67	222.3	407	438	0.8832
(12) 700, unused, from U. S. S. "Arkansas"	Oil as received	.....	211.0	319	355	0.937
	A	24.00	70.0	280	300	0.919
	B	24.96	142.0	330	355	0.9325
	C	27.57	303.0	368	416	0.939
	D	23.47	1,837.0	414	450	0.947
(13) 700, used, filtered, U. S. S. "Arkansas"	Oil as received	.....	186.0	326	370	0.9111
	A	17.44	71.5	288	346	0.912
	B	18.40	112.3	326	372	0.913
	C	17.66	163.0	360	398	0.910
	D	20.44	229.8	371	420	0.906
	E	26.06	547.0	417	490	0.910
(14) 705, unused, from U. S. S. "Arkansas"	Oil as received	.....	178.0	403	464	0.883
	A	21.95	108.0	350	390	0.878
	B	24.23	140.2	368	405	0.877
	C	22.83	185.0	374	405	0.880
	D	30.99	380.0	444	468	0.892
(15) 705, used, filtered, U. S. S. "Arkansas"	Oil as received	.....	186.6	410	440	0.888
	A	21.20	101.3	326	368	0.885
	B	22.32	142.3	362	430	0.881
	C	23.28	179.6	410	462	0.882
	D	33.20	390.2	455	500	0.894

* Fractions combined and then refractioned.

For the purpose of ascertaining the reduction of the vaporizing point of oil by the use of superheated steam, No. 702 oil from the same sample as used in the foregoing experiment was distilled by heat alone. The results as compared to distillation with superheated steam were:

	Dry Heat Distillation	Superheated Steam Distillation
Oil started to distill	690 F.	380 F.
52 per cent. of the oil distilled over at	740	535
80 per cent. distilled over at	...	550

When 52 per cent. of the oil was distilled by dry-heat distillation, the heat became so intense that the distillation was stopped for fear of melting the glass flask. The distilled oil from the dry distillation had a burned odor, which persisted.

If the fractionation of a lubricating oil as performed in this investigation did not decompose the oil, it should be possible to recombine the fractions and produce an oil which had the same properties as the original. This was done with No. 701, Run No. 4, and No. 703, Run No. 6. The fractions were proportionately recombined to form a lubricating oil, whose properties compared to the original were:

	Viscosity at 100 F.	Viscosity at 130 F.	Flash Point, F.	Fire Point, F.	Specific Gravity
No. 701, from oils laboratory	205.0	107.0	395	455	0.887
701, recombined from fractions No. 4	207.2	107.0	374	404	0.887
703, from oils laboratory	316.0	137.0	348	384	0.9251
703, recombined from fractions No. 6	302.0	128.8	336	378	0.927

All the conditions for the distillation of the oil were made as nearly perfect as possible to avoid decomposition or "cracking" of the oil. The large quantity of steam used in the distillation swept the oil vapors rapidly from the still, and prevented excessive condensation and overheating of the oil. The temperature of the steam and oil vapors leaving the still averaged only 10 to 15 deg. F. lower than the temperature of the oil in the still. This was a remarkably good condition to avoid decomposition or "cracking" of the oil. If, in distilling, the oil is allowed to become very hot and considerable condensed oil vapors are allowed to drop back into the hot oil, the heavy-oil residues are broken up into lighter-gravity oils and carbon is deposited in the still. In no case was carbon deposited in the residue oils of this investigation. It is also to be noted that the average specific gravity of the fractions is equal to the specific gravity of the original oil. If "cracking" or decomposition took place during the distillation, hydrocarbon gases would be evolved and the average gravity of the fractions would be much lower than the specific gravity of the original oil. Allowing for a slight loss in wetting the apparatus for distillation and condensation, the volume and weight of the fractions equaled the volume and weight of the original oil.

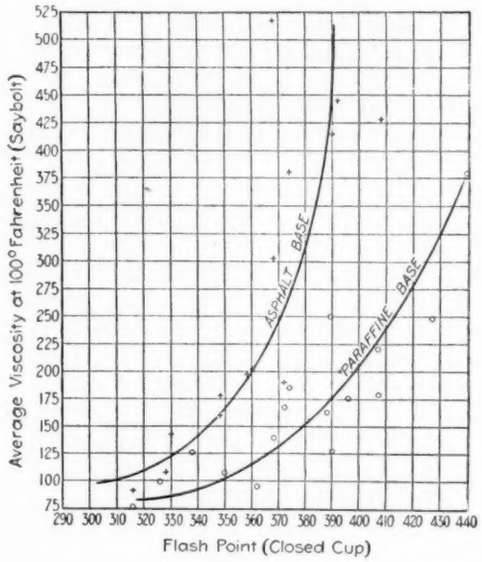


FIG. 4. ASPHALT BASE OILS TEND TO FLASH AT LOWER TEMPERATURES THAN PARAFFIN BASE OILS

When lubricating oils are fractioned as described in this investigation, then recombined to form the original oil and again fractioned, the second series of fractions have the same physical properties as the first series of fractions, as shown by oils, Run Nos. 6 and 7, 8 and 9, data given. By referring

to Figs. 1 and 2 it is at once apparent that like percentages of oil give the same points in the curves.

The method of fractional distillation described would be of no value if concordant results could not be obtained with the same oil, as shown by oils, Runs No. 1 and No. 2, and No. 3 and No. 4. By referring to Figs. 1 and 2, it is shown that like percentages of oil coincide; therefore, the method gives concordant results with the same oil.

The time required for fractioning a lubricating oil is not excessive, as shown by the data given. The total time required to heat the water in the boiler, the oil, etc., until the end of the distillation should not exceed four hours.

The sample of oil taken for distillation measured about 600 c.c. When this is fractioned into five fractions approximately 120 c.c. is allowed each fraction. Each fraction is more than sufficient for the careful determination of viscosity, flash and fire points, and specific gravity. These tests are generally recognized as the most important tests of lubricating oils. By dividing the original oil into four fractions, additional tests could be made which would in no way affect the accuracy of the result. In Fig. 1 will be found in graphical form the results obtained by plotting average viscosity of the oil fractions against fractions of oil, per cent. Average viscosity was obtained as follows: If an A fraction was 30 per cent. of the total weight of the oil taken for distillation and had a certain viscosity, the point was plotted on the 15 per cent. line, instead of on the 30 per cent. line, because the average viscosity would be the mean viscosity of the sample while it was growing from 0 to 30 per cent. The point was proved experimentally by combining equal volumes of known viscosity A and B fractions and determining the viscosity of the mixture. The mixture A and B fractions could be considered as an A fraction. The viscosity found did not come above the total percentage of A and B, but it did give the average viscosity of A and B, or a point at $\frac{\text{A plus B}}{2}$ per cent.

Instead of a lubricating oil being composed of oils all having the same viscosity, Fig. 1 shows that lubricating oil is composed of a large number of oils having a wide range of viscosity, and also shows that the viscosity of an oil, as it is known to the trade, is simply the average of the viscosities of all the component oils of a lubricating oil. From Fig. 1 we find that No. 700 contains 40.9 per cent. of oil with a viscosity below 200 sec. Saybolt and 59.1 per cent. with a viscosity above 200 sec. Saybolt at 100 F. From Fig. 1 the following tabulation might be drawn:

	Percentage Composition by Weight		
Name of Oil	Vis. Below 140 Sec.	Vis. 140 to 500 Sec.	Above 500 Sec.
No. 703	25.0	39.5	35.5
702	29.0	43.0	28.0
700	38.5	38.5	23.0
704	17.0	63.0	20.0
701	30.5	54.5	15.0
705	36.0	74.0	0.0

Considering the purpose for which the oils are intended it is extremely doubtful if a single argument could be brought forward to justify the presence of such a large percentage of oils having a viscosity below 140 sec. and above 500 sec. Saybolt. These light and heavy oils are unsuitable for lubrication, and it is not logical to say that the mixing of two unsuitable oils will make a good lubricant.

It is not the object of this investigation to pass judgment on the quality of the foregoing oils, but rather to indicate which component oils of a lubricating oil should be in greatest abundance. The light oils of a viscosity below 140 sec. Saybolt are undesirable because in lubricating machinery they are exposed to conditions of heat, steam and agitation which rapidly vaporize them, and consequently alter the viscosity of the lubricating oil and shorten its life. The heavy oils of a viscosity above 500 sec. Saybolt are undesirable because they are more liable to decomposition than those of lighter viscosity, producing in decomposition tarry or carbon deposits, causing engine troubles. These heavy oils offset the light ones and give a viscosity of a medium lubricating oil. When mixed with a light oil these heavy ones do not possess the properties of a heavy lubricating oil—that is, great molecular cohesion; but they temporarily possess the properties of a medium lubricating oil, differing from a good medium lubricating oil in that they change rapidly in viscosity.

From preceding data it is apparent that the life of a lubricating oil in service can be relatively estimated. Lubricating oils containing a large percentage of component oils with a viscosity of 140 to 500 sec. Saybolt at 100 F. should give much longer service than those low in these component oils.

In Fig. 2 will be found in graphic form the results obtained by plotting average viscosity of used and unused oils against fractions of oil, per cent. by weight. The oils tested were No. 700 and No. 705, obtained from U. S. S. "Arkansas." The used oils had been in the system 100 hr. No. 700 oil contains 38.5 per cent. of component oils with a viscosity of 140 to 500 sec. Saybolt. No. 705 contains 74 per cent. of component oils with a viscosity of 140 to 500 sec. Saybolt. In view of foregoing statements, No. 705 should be more stable or less changeable in viscosity than No. 700. This is true, as shown from the data given and from Fig. 3.

Attention is especially called to Fig. 3 for the reason that the changes in the two oils of the used and unusued are opposite in direction. No. 705 changes with use according to what we would expect from the literature on lubricating oils, that is, grows heavier in viscosity with use; No. 700 reverses and grows lighter with use.

The decrease in viscosity and specific gravity of No. 700 oil, especially the decrease in gravity of the heavy ends (see data, run 13), is taken as an indication of the decomposition or "cracking" of the used oil.

In Fig. 2 will be found in graphic form the results obtained by plotting the average viscosity of the oil fractions of paraffin- and asphalt-base oils (data given) against the average temperature of volatilization of the oil fractions with superheated steam. All authorities on lubricating oils claim that the ideal lubricant is one requiring a very high temperature to volatilize, and possessing minimum fluid friction, low viscosity when measured in seconds Saybolt.

In view of the foregoing results and for future reference it is to be noted that for the same viscosity, Saybolt, asphalt-base oils are far more volatile than paraffin-base oils. If lubricating oils were not made up of a conglomerate of oils with varying temperature of vaporization and viscosity, as they are at present, but were composed of component oils of approximately the same viscosity and with the same temperature of vaporization, there would be a definite relation between the viscosity and volatility of oils.

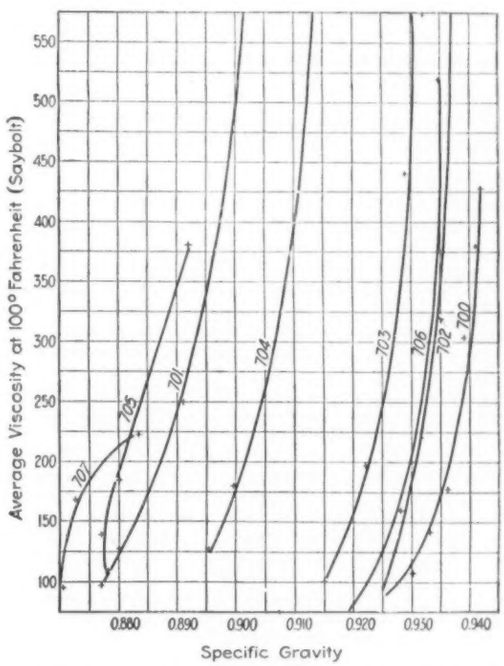


FIG. 5. SHOWING INCREASE IN SPECIFIC GRAVITY FOR INCREASE IN VISCOSITY. IMPORTANT IN CONNECTION WITH OILS IN SERVICE

In Fig. 4 will be found in graphic form the results obtained by plotting average viscosity of the oil fractions of paraffin- and asphalt-base oils against the flash point in degrees F. of the oil fractions. The curves of asphalt- and paraffin-base oils show the general tendency of asphalt oils of the same viscosity to flash at lower temperatures than paraffin-base oils of like viscosity. From data given attention is invited to the fact that, when a lubricating oil is fractioned, the first fractions distilled have a much lower flash and fire point than the original oil; in other words, by mixing heavy oils with light, the flash and fire points of the mixture are considerably raised above the flash and fire points of the lightest component oil. By subjecting a lubricating oil to fractionation as described information is obtained as to the choice of a lubricating oil possessing the requisite viscosity and having a maximum flash and fire test.

In Fig. 5 will be found in graphic form the results obtained by plotting average viscosity of the oil fractions against specific gravity of the oil fractions. It is shown that for each

individual oil there is an increase in specific gravity for proportional increase in viscosity. This point is important when considering used oils; for instance, the loss in specific gravity of "used" No. 700 (oil No. 13) might be accounted for as the loss by vaporization of light oils of high specific gravity, were it not known that there is a gradual increase of specific gravity with increase of viscosity and temperature of vaporization of the component oils of No. 700. Moreover, knowing the specific gravity of the oil fractions of the "unused" oil, and from the loss in specific gravity of the fractions of the used oil, we are able at once to point out the component oils which have undergone decomposition in use. In the case of "used" No. 700 it was shown that the high-viscosity and high-temperature vaporizing oils underwent decomposition.

The method described in this investigation meets all the requirements of a successful laboratory routine method for examining mineral lubricating oils as to the quality and quantity of component light, heavy and intermediate oils.

The investigation of samples of representative oils, showed that there was considerable room for improving lubricating oils by eliminating light and heavy oils, and by compounding mineral lubricating oils from mineral oils having approximately the same viscosity, flash and fire points, specific gravity and temperature of vaporization. [This is possible in the laboratory and may be commercially feasible.—Editor.]

Marked differences between asphalt- and paraffin-base oils in regard to temperature of volatilization, viscosity, flash and fire points, and specific gravity were noted. And all of these are, of course, highly important properties.

Since all lubricating oils, when treated with chemicals, are either unacted on or give reactions not generally understood, it would seem highly important that the method of fractional distillation be developed to its fullest extent; for the vaporizing temperature is one of the most valuable means of identifying an oil; especially applicable is this method to lubricating oils, for it increases considerably the use and value of standard tests already familiar.

From the mechanical viewpoint, provided the oil is well refined, we are only interested in the viscosity of a lubricating oil (latest researches show that the viscosity controls the coefficient of friction) and the maintaining of this viscosity without change when in use. It is well known to the service what the viscosity of the lubricating oils should be for the different purposes intended, but heretofore there were no known methods which would indicate between equally well-refined oils which would longest retain their viscosity without change when subjected to severe use. The knowledge that shows a lubricating oil will retain its viscosity without change when subjected to severe use is then equally as valuable, if not more so, than the knowledge of the original viscosity. The maintaining of the viscosity without change when in service is dependent on the following factors: Mineral lubricating oils should be compounded from oils which vaporize within narrow limits, and from oils having relatively the same viscosity, specific gravity and flash and fire points.

Notes on Carburetion*

By Edward E. Dean

SYNOPSIS—The principles of carburetion are explained, and the three general types of carburetors are described. The use of kerosene is also discussed.

Carburetion in this paper will be confined to the induction principle—that is, one in which the flow of air and fuel is induced and maintained by air displacement. It will therefore be apparent that the flow must vary from zero when the piston is at rest to maximum velocity when the piston has attained its maximum velocity. As soon as the piston begins to move on its induction stroke, air displacement occurs and the pressure in the passages between the carburetor and piston head become negative, decreasing gradually until maximum velocity is reached.

The simple carburetor consists of a tube of constant diameter, having a fuel jet in communication with the air flow. As the quantity of both air and fuel vary as the square of the tube diameter, it would seem necessary only to so proportion the tube and fuel duct to attain a proportional mixture for all air velocities.

If one were dealing with a perfect gas or were able to so deliver the fuel to the air stream thoroughly atomized, homeogeneously mixing it with the air without any expenditure of energy of the air stream, a proportional mixture of the air and fuel for all speeds might be expected. This, however, is not possible as friction head, viscosity and other retarding influences that vary with the velocity must be contended against.

Why does a simple carburetor seemingly deliver an increasingly richer mixture as the air velocities increase? This in the opinion of the writer is due to inefficient atomization when air velocities are low and lack of thorough saturation of the air stream with the fuel molecules. To offset this condition fuel must be admitted under less retardation, or in other words, the fuel orifice must be increased. As the air velocities increase, so also does the efficiency of atomization. The increase in the fuel orifice which was necessary for low air velocities now becomes excessive, consequently the quantity of fuel molecules becomes greater as the air velocities increase, resulting in an over-rich mixture. The simple carburetor must of necessity be limited in its range of capacity and is at best wasteful of fuel.

A combination of the mixing valve and the simple tube carburetor becomes the foundation of our present instrument. The range of the mixing valve is far more limited than the simple tube, the tendency being toward rapid impoverishment as the air velocities decrease with air-valve opening. It will be noted that its action is the reverse of the simple tube carburetor. The mixing valve delivers an increasingly weaker mixture as the air quantities increase, while the tube delivers a richer mixture under the same conditions.

Attempts to correct the tendency to over-richness exhibited by the simple carburetor led to the early adoption of the auxiliary air valve. The popular conception of its function seems to be that of correction by diluting with air the over-rich mixture delivered by the simple tube portion of the carburetor. This is true, but its dual function is to not only add an extra amount of fresh air, but more particularly effect a modification of the air velocities at the fuel jet; that is, it increases the air supply, which decreases the tension on the air flow at the jet and consequently effects a reduction of inspiration, resulting in a weakened mixture.

As will be apparent from the foregoing, the auxiliary portion, be it spring or weight, can serve but one purpose—that is, to correct an over-rich mixture and at one point at a time.

It therefore follows that no adjustment of spring tension can do more than slightly modify this tendency toward impoverishment of the mixture, while the addition of various forms of subsidiary springs becoming operative only at some point of valve opening can do no more than correct the air at one given point and then start, as it were, merely a new scale of errors. This is not only true when springs are used, but is an unavoidable fact when correction is attempted in this manner by any means.

The multiple-jet type may be compared to the auxiliary-air type, being an attempt at correction by the addition of jets as needed, and is subject to the same criticism as pointed out in the auxiliary air-valve construction. Results approaching perfection may be attained by this method, but of necessity they must be sensible in construction. The jets in the smaller sizes must be minutely small if any number are to be employed, with consequent troubles from water and foreign matter in the fuel.

The variable-fuel orifice type, in which a tapered valve is withdrawn from the fuel orifice in relation to the quantity of air passing through the carburetor, in principle approaches the ideal. However, when one considers that the fuel and air ratio by volume is about one to eight thousand, and as this method is a direct graduation of the one part, its sensitiveness will be apparent.

The successful carburetor must accomplish as fully as possible atomization of the fuel at all working air velocities and a thorough saturation of the air stream with fuel molecules, consistent with volumetric efficiency of the motor, and must so deliver the mixture to the manifold. It must be simple, with no more moving parts than absolutely necessary, and its principle must consist in controlling the air pressures which directly effect inspiration.

To successfully utilize kerosene or other fuel oils in an internal-combustion motor of the carburetor type, it becomes necessary to deliver the fuel charge to the combustion space

*From paper before the National Gas Engine Association convention at Chicago, June 27-29, 1916.

thoroughly saturated with the fuel molecules in a correct proportion for all air velocities. The accomplishment of this depends upon several factors.

The correct design of carburetor would be one in which the air velocities must be maintained sufficiently high at all speeds to effect a thorough atomization of the fuel stream from the jet and at the same time not so high as to cause wiredrawing resulting in a partial charge and loss of power.

The writer would divide the process of carburetion of air and fuel into three stages, the carburetor being responsible for the first stage, the manifold and inlet passages the second stage, and the period of compression the third and final stage.

Assume that the mixture has been delivered to the manifold in a thorough state of saturation, which is the completion of the first stage. Throughout the second stage this thorough admixture of air and fuel not only must be maintained, but must be assisted by partial vaporization and delivered to the third stage. In the third stage occurs gasification due to compression, which accomplishes a closer commingling of the fuel molecules with the air, resulting in rapid flame propagation. This is assisted materially by the rise in temperature due to compression and heat from the cylinder walls. Summarized, we find: First stage, atomization; second stage, vaporization; third stage, gasification. Where these three stages are accomplished successfully, the use of fuel oils is possible.

TEMPERATURE DROP IN INCOMING AIR

The temperature of the incoming air is subject to considerable change in passing through a carburetor dropping practically 50 per cent. under normal conditions. This is due to expansion after leaving the tube restriction and loss from evaporation of the fuel.

As kerosene begins to give off a vapor at about 80 deg. F., it follows that the temperature must not fall below this figure at any time and should be somewhat higher consistent with volumetric efficiency. To offset this temperature drop, we may increase the temperature of the incoming air. However, this is not enough. If we could maintain a suspension of fuel molecules in the air stream without any deposition, this would be sufficient. Unfortunately we must have bends and turns in fuel passages, and as the fuel molecules have a greater specific gravity than the air, they will be impinged or thrown against the sides and remain in a liquid state. This means an impoverished mixture. This must be avoided and can be by applying heat to the sides or walls of the manifold, which will materially assist in revaporizing these molecules and sending them back into the air stream.

Modern practice seems to point out the advisability of applying heat to assist carburetion. There are at least three practical methods being used successfully: Raising the temperature of the intake air, heat jacketing the manifold, and applying heat directly to the fuel supply. The successful burning of the lower-grade distillates depends upon at least the two former means. The third may be employed with good results.

In the application of heat we are attempting to maintain a temperature within the carburetor and passages sufficiently high to assist and maintain vaporization. This is best accomplished through the medium of raising the temperature of the intake air. Preheating the fuel will assist in atomization, but owing to the extremely small amount entering the air stream, can have but slight effect in maintaining the necessary temperature for vaporization. Applying heat to the fuel passages is very necessary, especially where the charge has some distance to travel. Deposition of fuel must inevitably take place, and unless this can be got back into the incoming charge, it must arrive at the combustion space in an impoverished condition. It is therefore very essential that heat be applied to the manifold and brought as near to the carburetor as possible.

HEAVY FUELS REQUIRE MORE HEAT

As the specific gravity of the fuel increases, so should the temperature of heat application increase. With present-day gasoline much benefit could be derived by jacketing the manifold with hot water throughout its entire length; but with kerosene, hot water is not sufficient—exhaust gas must be used. Here arises a situation which does not lend itself to direct application when best results are sought.

At low motor speeds, when air velocities through the carburetor are low and atomization is incomplete, we should have the highest temperatures, especially around the manifold jacket. The temperature and quantity of exhaust gas is limited at this time. Therefore the supply of exhaust gas is inversely proportional to the needs. To offset this condition a governing means might be employed so as to utilize all the exhaust at low speeds, controlling it as much as may be found necessary for the increase in speed.

The manifold should be as short as possible consistent with good diffusion and proper distribution. It should have few bends and large radii, avoiding pockets and change of cross-section to such an extent as shall affect the velocity of the incoming charge.

American Society for Testing Materials

The nineteenth annual meeting of the American Society for Testing Materials, which was held at the Hotel Traymore, Atlantic City, N. J., June 27 to 30, was the most largely attended and successful meeting in the history of the society. More than 750 members and guests were present under ideal weather and other convention conditions.

The first business session was held on Tuesday morning, June 27. Announcement was made of election of officers for the ensuing year, as follows: President, A. A. Stevenson, vice-president of Standard Steel Work Co., Philadelphia, Penn.; first vice-president, W. H. Bixby, superintendent of National Malleable Castings Co., Indianapolis, Ind.; second vice-president, S. S. Voorhees, engineer-chemist, Bureau of Standards, Washington, D. C. Messrs. S. H. Bassett, John Brunner, G. W. Thompson and F. E. Turneaure were elected to places on the executive committee for terms expiring in 1918. The executive committee subsequently announced that it had reëlected as secretary-treasurer Prof. Edgar Marburg, of the University of Pennsylvania, Philadelphia, Penn.

The only technical paper presented at the first session was the report of the Committee on Wrought Iron. This report, which was adopted, recommends the correction of the table of standard minimum weights in the standard specifications for lap-welded iron boiler tubes to harmonize with the B.w.g. thicknesses and the standard specifications for steel tubes, allowing weights 2 per cent. less than those of steel tubes for the corresponding diameters and gages. The afternoon and evening sessions were mainly devoted to miscellaneous materials, including the report of the Committee on Methods of Sampling and Analysis of Coal.

PRESIDENT'S ADDRESS

The first order of business of the evening session was the annual address of President Mansfield Merriam, which had for its leading subject an explanation and review of the organization and work of committees of the society. His remarks showed that when the society was formally organized in May, 1902, as an outgrowth of the American Section of the International Association for Testing Materials, the methods of committee work were adopted and have since been continued with certain modifications and improvements. The society has now actively at work 37 committees, and 15 of these have 89 subcommittees. These are classified under five groups: A, designating iron and steel; B, nonferrous metals; C, cement and concrete; D, miscellaneous materials; and E, miscellaneous subjects. The largest committee has 97 members, the smallest four members. Altogether the membership of the 37 committees is 913, which is nearly one-half the membership of the society, but since some men are on two or more committees it is probable that only about one-third of the members are engaged in committee work.

The fourth session, on Wednesday morning, devoted to papers and discussion on steel and iron, had the largest attendance of any of the business sessions.

The subjects presented of greatest interest to power-plant engineers were the report of the recommendations of the Committee on Steel of proposed tentative specifications for boiler and firebox steel for stationary service, and a paper on "Recrystallization as a Factor in the Failure of Boiler Tubes," by A. E. White and H. F. Wood.

BOILER STEELS

In its report last year the committee announced its intention of "giving special study to the subject of additional tests of boiler plate to determine the uniformity of the metal throughout the plate." To this end the committee recommended revisions in the society's standard specifications for boiler and firebox steel, providing for the following features:

(a) To check the uniformity of the metal, the tension test specimen is to be taken longitudinally from the bottom and the bend test specimen transversely from the middle of the top of the finished rolled material. (In present practice both are taken longitudinally from the bottom.) The bend test specimen is to be tested cold only, omitting the quench-bend test, and the requirements as to cold bend have been suitably modified. In addition,

(b) The requirements as to permissible variations in weight and thickness have been modified as indicated earlier in the report; and

(c) Provision has been made for match-marking of test coupons.

Proposed Tentative Specifications for Boiler and Firebox Steel for Stationary Service—The committee recommends that these specifications, which are appended to the report, be published as tentative. The presentation of these specifications has resulted from the consideration of the question of revising the "Standard Specifications for Boiler and Firebox Steel" to agree with the provisions of the Boiler Code drafted by the American Society of Mechanical Engineers, reference to which was made in the report last year.

It was thought best to prepare separate specifications for use in stationary service, to which service the American Society of Mechanical Engineers Boiler Code applies. The proposed "Tentative Specifications for Boiler and Firebox Steel for Stationary Service" have been modeled upon the society's "Standard Specifications for Boiler and Firebox Steel" in their proposed amended form and contain the three new features referred to above in connection with the latter. In this respect they differ from the specifications in the A. S. M. E. Boiler Code and further in the requirements for tensile strength of firebox steel, which in the proposed specifications are 55,000 to 65,000 lb. per sq.in., while the A. S. M. E. Code specifies 55,000 to 63,000 lb. per sq.in. or, if desired, a steel of lower tensile strength having a range of 8,000 lb. per sq.in. Similarly with respect to flange steel: The proposed specifications call for 55,000 to 65,000 lb. per sq.in., while the A. S. M. E. Code specifies that grade or, if desired, a steel of lower tensile strength having a range of 10,000 lb. per sq.in. The committee intends to give further consideration to this feature before recommending that the specifications be adopted as standard.

A paper presented on "Recrystallization as a Factor in the Failure of Boiler Tubes," by A. E. White and H. F. Wood, is summarized as follows:

Frequent replacements of tubes in certain boilers that were run under high rates of evaporation for days at a time during the winter months so interfered with efficient operation that the company in control of these boilers requested a detailed study of the influences affecting the properties of tube metal. This paper presents simply one phase of the subject, a phase dealing with conditions producing crystal growth.

A careful summary of the researches which have been made in an attempt to explain the exact phenomena of recrystallization on deformed low-carbon steels is presented. The laboratory methods employed in the investigation are briefly described, and the results secured are given.

It has made possible the formulation of a hypothesis giving the time-temperature relationship affecting crystal growth in deformed low-carbon steel at temperatures lying between 675 deg. and 550 deg. C. On the assumption that the hypothesis would hold equally well for all lower temperatures, it is evident that at atmospheric temperatures thousands of years would be necessary for the development of crystal growth in deformed iron having a low carbon content.

The investigation has also resulted in showing that, due to the combined effects of high rates of evaporation and a slight scale deposit, the temperature attained by some of the tubes reached a high degree, so high, in fact, that if the metal had previously undergone deformation at temperatures below the 850 deg. C. point, and if the time during which it remained at such temperature was sufficient, coarse crystals resulted. These coarse crystals produce a marked deterioration of the good properties found in the tube metal and contribute their share to a trouble spoken of as "bagging."

To offset such a state of affairs, it is held highly desirable to free the water from all scale-producing minerals. In the plant in question this feature is receiving due attention. It is furthermore suggested that in the production of boiler tubes a serious attempt be made to secure a metal which, when in state of strain, will not be subject to grain growth. It is felt that a tube with a higher carbon content than that now generally introduced may possibly fulfill such a condition. At all events, the matter is about to undergo a trial.

The business session of Wednesday evening was devoted to hearing summaries and discussions on the report of the Committee on Methods of Testing.

The executive committee reported on a resolution introduced by Prof. Henry M. Howe at the morning session in relation to the adoption of the Centigrade thermometric scale. After some discussion a resolution on the subject was passed as follows:

"It is the sense of this meeting of the American Society for Testing Materials that the efforts being made to obtain legislation requiring the use of the Centigrade scale in all future Government publications should be heartily approved."

Thursday morning's session was devoted to cement and concrete, and the evening session was occupied by reports, papers and discussions on ceramics, road material and gypsum.

Friday morning's session was devoted to nonferrous metals, and at the evening session reports and papers were presented on miscellaneous materials. A paper on "Emulsification of Mineral Oils, Apparatus and Test Method" was presented by P. H. Conradson. The author described a simple apparatus and test method to determine the emulsibility and demulsification of lubricating oils such as steam-turbine, steam-engine and crank-case oils. Another paper on the subject, entitled "Quantitative Test for Resistance of Lubricating Oils to Emulsification," was presented by W. H. Herschel. It described laboratory tests by which nonemulsifying oils may be selected. Abstracts of these papers will be given in a future issue.

ENGINEERING AFFAIRS

The American Society of Heating and Ventilating Engineers will hold its semiannual meeting at Detroit, July 19 to 21.

The American Society of Safety Engineers will hold its next regular meeting at the Engineering Societies Building, 25 West 39th St., New York, July 26, at 8 p.m.

The Universal Craftsmen Council of Engineers will hold its thirteenth annual convention at Pittsburgh, Penn., during the week beginning Aug. 8. G. G. Brown and his committee are hard at work in an earnest endeavor to make the meeting a big success.

At the National Gas Engine Association annual convention, held in Chicago June 29, O. H. Fisher, president of the Union Gas Engine Co., Fred. H. Glover, vice-president of the Emerson-Brantingham Imp. Co., and H. G. Diefendorf, of the Gray Motor Co., were elected to the executive committee to serve for three years, and C. E. Bement, secretary and general manager of the Novo Engine Co., was reëlected president.

The Engineering Foundation, the initial endowment of which was received last year from Ambrose Swasey, of Cleveland, and which is administered in the interest of scientific research and the good of mankind through the engineering profession by trustees from the national societies of civil, mining, mechanical and electrical engineers, representing thirty thousand engineers in all, held, after a dinner June 25 at the University Club, New York City, an important meeting at which it was decided to offer the services of the Foundation to the National Academy of Sciences of the United States to accomplish the federation of all the research agencies of the nation—governmental, university and private—with the object of encouraging the application of scientific principles to American industries and the employment of science in the national defense, which the possibility of war renders particularly important at this time. The meeting decided to spend from $8,000 to $15,000 per year on a competent executive secretary to assist in the organization. An important addition to the financial resources of the Foundation was announced from Ambrose Swasey, who was a guest of honor.

OBITUARY

WILLIAM A. WARMAN

William A. Warman, in charge of the design of special machinery and research work for the Keller Mechanical Engraving Co., Brooklyn, N. Y., for the past 12 years, died at Saranac, N. Y., on July 2, 1916, after a lingering illness.

Mr. Warman was born in Latrobe, Ohio, in 1861. His first work as a young man was in the domain of invention, and for several years he spent most of his time and effort in the development of a variety of mechanical inventions which eventually reached the world as commercially practical devices. The inventive faculty remained as one of his chief characteristics throughout his mechanical career, for in later pursuits, although associated with manufacturing propositions, he seemed to naturally turn toward those sides of his problem that possessed opportunity for original work.

Before he became interested in the mechanical-engraving development, he had been superintendent and designer for the Ritter Dental Manufacturing Co., Rochester, N. Y. Later on he became connected with the Dick Press Guard Manufacturing Co., which was reorganized at the time of his acquisition to manufacture press guards of his design.

His mechanical-engraving work preceded by a number of years his connection with the Keller Mechanical Engraving Co. For the manufacture of an engraving machine of his own design, he organized the Warman Co., which was absorbed by the Keller company in 1905. In recent years he had given considerable study to gas-turbine and air-compressor work, in which fields he had not fully completed his experiments.